THE HIMALAYA PROJECT

A project conceived by members of the ICES Foundation and its global partners to assist in the preservation, development and understanding of a critically important ecological and social-economic region which plays a major role in the future trajectory and well-being of our entire planet.

THE HIMALAYA PROJECT

There is an opportunity to consolidate and bring together the multiple sciences and diverse studies that relate to this important region of the world, and thereby build a knowledge system to improve the region's resilience to damage and losses from natural and man-made disasters while improving the quality of life for inhabitants in the many villages, towns and cities downstream.

The Himalayan Mountains have enormous impact on surroundings near and far, with at least 15 nations directly impacted by its unique weather and climactic conditions, its glaciers and rivers, and its overarching biogeophysical expanse.

Although occupying just 11% of the world's land surface, together these15 nations make up 45% of the world's present population. But their cooperation and shared wisdom is unfortunately less than to be desired.

This document contains a project outline that has been conceived to improve communications and future collaboration between the countries involved, and to set them on a course for producing a ***unified knowledge system*** of the region. Our goal is to underpin the long-term creation of ecological civilizations with well harmonised bioregions and eco-cities in an era of changing climate and frequent natural hazards.

The Himalayan Project is a major element in the global vision and mission of Geneva-based, non-political, not-for-profit ***ICES Foundation (International Centre for Earth Simulation)***
www.icesfoundation.org and in cooperation with the following contributing partners, namely:

The Institute for Environmental Science (IES), University of Geneva, from which Professor Martin Beniston led the European Union, funded ACQWA Project – a 5 year project to integrate the multiple water systems and sub-systems of the European Alpine Region.:
http://www.unige.ch/environnement/index_en.html
http://www.unige.ch/climate/Publications/Beniston.html
http://www.unige.ch/climate/Projects/ACQWA.html

The Institute of Global Environment and Society (IGES), George Mason University, from which Professor Jagadish Shukla chairs a post-graduate program in Climate Dynamics, with special emphasis on the impact of a changing climate on the Asian Monsoons:
http://www.iges.org/home.html
http://www.iges.org/people/shukla.html
http://aoes.gmu.edu/climate_dynamics
http://icesfoundation.org/UsersFiles/FCKeditorFiles/file/Asian%20Monsoons%20in%20a%20Changing%20Climate.pdf

and

The Ecological Sequestration Trust (UK), from which Professor Peter Head leads an integrated approach to city-region resilience, holistic planning, and underlying business models:

http://ecosequestrust.org/category/about/
http://ecosequestrust.org/our-people/executive-team/
www.youtube.com/embed/VmHAWkeD0ok?rel=0

Other partners are expected to join this effort as soon as the funding mechanisms are secured.

AN OVERVIEW OF THE HIMALAYAS

The Himalayas are a young seismically active mountain range arching across the Tropic of Cancer in Asia with over 100 peaks exceeding 7000m that are still being pushed upwards by the tectonic collision of the northward moving Indo-Australian Plate with the Eurasian Plate. The mountains extend for 2,400 km in length and between 150km in width at the eastern end to 400 km width in the west.

High altitudes have induced the formation of over 35,000 glaciers within the Himalayas, forming the source of major river systems that flow both north and south into neighboring countries. The mountains also play a major role in the flow and direction of large-scale monsoon weather systems that regularly impact the region.

Geologically, the Himalayas and their immediate surroundings are often referred to as a 'Third Pole' of Planet Earth. The region suffers frequent large-scale disasters from earthquakes, avalanches, mudslides, rock falls, floods, and extreme weather events. In addition, the glaciers are in serious retreat due to global warming, and there is a shift in much of the biological makeup of the region due to such warming.

Socio-economically, the Himalayas hugely impact all food, agriculture, energy, transportation, industrial, and public health systems within the countries that depend on its rivers. There is a patchwork of micro and macro climactic conditions created by the mountain range. Because of long-term historical conflicts however, many of these countries do not pro-actively share or coordinate their knowledge of the many physical aspects of mountain life, even though Mother Nature herself functions across national borders in a very fluid and transparent manner.

The 16 nations that have most at stake are listed as follows in order of national population size:

	Population	Land Size
China	1,354.0M (12/2012)	9,569.90M km^2
India	1,210.6M (03/2011)	2,973.19M km^2
Pakistan	183.8M (07/2013)	856.69M km^2
Bangladesh	152.5M (07/2012)	130.17M km^2
Vietnam	88.8M (07/2012)	310.07M km^2
Thailand	65.9M (09/2010)	510.89M km^2
Myanmar	53.2M (07/2013)	653.51M km^2
Malaysia	29.8M (07/2013)	329.61M km^2
Nepal	26.5M (06/2011	140.80M km^2
Afghanistan	25.5M (01/2013)	652.23M km^2
Cambodia	15.1M (07/2013)	176.52M km^2
Tajikistan	8.0M (04/2013)	141.51M km^2
Laos	6.6M (07/2013)	230.80M km^2
Kyrgyzstan	5.6M (07/2012)	191.80M km^2
Mongolia	3.0M (07/2014)	1,564.12M km^2
Bhutan	.7M (07/2012)	47.04M km^2

Regional Population = 3,230M (45% of 7,100M world population according to UCSB world population clock).
Regional Land Size =18,291M km^2 (12.3% of 148,940M km^2 world land size)

THE TIBETAN PLATEAU

With an average elevation of over 4500m and covering an area of 2,500,000 square kilometers, this region is known as the 'roof of the world' and is the headwaters of most streams in the surrounding region, and is itself surrounded by numerous mountain ranges. Furthermore, the seasonal monsoon wind shift and weather associated with the heating and cooling of the Tibetan Plateau is the strongest such monsoon on Earth.

Such well known rivers as the Yangtze, Yellow, Indus, Brahmaputra, Salween and Mekong originate in the Himalayan and Tibetan Plateau region and supply a lifeline of water, food, transport and energy to neighbouring countries. However, these rivers cross national boundaries and are therefore in high dispute with respect to water usage rights, hydroelectric damming, fishing and pollution control.

Qin Dahe, the former head of the China Meteorological Administration and winner of the 2013 Volvo Environmental prize (http://www.environment-prize.com/) said:

"Temperatures are rising four times faster than elsewhere in China, and the Tibetan glaciers are retreating at a higher speed than in any other part of the world. In the short term, this will cause lakes to expand and bring floods and mudflows. In the long run, the glaciers are vital lifelines for Asian rivers, including the Indus and the Ganges. Once they vanish, water supplies in those regions will be in peril."

DESIGNING ECOLOGICAL CITIES and EXPANDING TRADITIONAL CITIES

In the past 30 years, China's urban population alone has jumped to more than 700 million from less than 200 million, causing violent clashes over expropriation of farmland for development, as well as water shortages, energy shortages, transportation difficulties, air pollution and other problems. The same trends can be observed in many parts of the 15-country region.

Developing smart, intelligent and eco-friendly cities is now the priority in the years ahead, and this will require a far-sighted understanding of local, regional and global climate change, especially with respect to seasonal monsoons, changing mountain snow pack, seasonal snow melt, river flows and lurking seismic hazards.

Protection of eco-services from important bio-regions is an equally important aspect of future development planning, since such bio-regions act to support the health of nearby villages and cities. Long-term water security, food security, public safety and quality of life are all at stake.

UNIFIED KNOWLEDGE SYSTEM

Although a vast amount of local knowledge is currently available, this knowledge is neither systematically compiled nor shared between the countries of the Himalayan Mountain Region. Nor is this knowledge updated with a clear understanding of local impacts from global climate change, global warming, and global sea-level rise. Our proposal is to help create this ***Unified Knowledge System*** by means of a consortium of international, independent, non-political organizations led by the ICES Foundation, and in cooperation with local and international bodies of high repute, such as:

ICIMOD: http://www.icimod.org/?q=abt
SASCOF: http://dhm.gov.np/uploads/getnotice/693527908sascof4_general%20information_nepal.pdf
LASG/IAP/CAS: http://www.lasg.ac.cn/

THE BASIS AND STRUCTURE OF THE UNIFIED KNOWLEDGE SYSTEM (UKS)

The basis of the UKS is a high-resolution digital elevation map (DEM) which provides a surface rendering on the complex geography that can be found throughout the entire Himalaya Region and to which the following multiple layers of additional data are attached: built environment, infrastructure, utility grids, power plants, transportation systems, land cover, farming and agricultural activities.

From this base map, a very large 3D file of information that describes all weather, hydrological and climate variables on a real-time basis will be accessible. This 'big data' file will be kept up-to-date by feeder data-streams coming in from local and regional authorities, and will include identifiable and quantifiable emissions information.

In addition to this surface information, the underlying sub-surface structure of the entire region will be defined and accessible from the base DEM, to the extent to which it is known. This file will contain all soil data, aquifers, geological faults and mineral deposits, as well as localized magnetic readings and historical seismic events.

Areas of local hazard will be of particular importance, and the best multi-physics, multi-science methods will be used to pinpoint the position of most likely occurrences. Hazards such as heavy rain, hail, flood, avalanche, glacial lake outbursts, landslide, mudslide, earthquake, fire, heat-wave, drought and many other hazards will be tracked and identified.

The essence of the UKS is an integrated holistic compilation of all the bio-geo-physical knowledge that is already known throughout the region, along with real-time feeds that keep the dynamic status of the territory available in an openly accessible manner.

A vast amount of satellite-derived Earth Observation data will feed into the system, and will add value to specific user enquires. Such satellite data will emanate from both geo-stationary satellites as well as constellations of microsatellites operated by private companies.

Using such multi-level data captured and available within or linked to the UKS, a modelling, simulation and visualization service will be available that allows the user to drill down, access and visualize all elements of interest on a hyperlocal basis. This is essentially a '*real-time big data predictive visual analytics*' function that will provide 'look ahead' capabilities and project the forward state of the region, or any area of local interest.

Finally, the UKS will ingest and assimilate as much social-economic data as possible so as to project the forward evolution of geographical developments and thereby to understand any harmful impacts on the natural bio-geo-physical system, both short term and long-term. As a consequence, planners will be able to ask 'what if' questions that help clarify the consequences of adding hydro-electric dams to river systems, or changing land cover and agricultural methods, or extending city boundaries and infrastructure.

In particular, the UKS will assist nations to communicate and coordinate their skills on matters of common interest, and to assist each other in such important areas as risk mitigation, and food-water-energy security.

THE IMPORTANCE OF EARTHQUAKE LOSS ESTIMATES TO THE HIMALAYA REGION

The Himalaya - collision zone between India and Asia - generates some of the deadliest earthquakes on this planet. In addition, this collision radiates compressive energy into the Chinese provinces to the north, east and northeast of the Himalayas that leads to great and devastating earthquakes. With more than 3 million deaths due to earthquakes, China leads the world in earthquake fatalities at this time (Utsu, 2002; ICES archives 2015). The total number of earthquake fatalities in the Himalayan belt from China to Iran exceeds 6 million. According to the loss predictions of Wyss (2005), India with its large population may eventually surpass China as the country with the largest number of accumulated earthquake fatalities. Therefore, we pay more attention to earthquake risk reduction along the southern front of the Himalaya.

The ICES Foundation, using its QLARM loss estimate system (Trendafiloski et al., 2011) and expert staff, will train and coach Himalaya countries on the use of the QLARM system for mortality and injury loss estimates associated with large earthquakes - in both *near real-time mode*, and in *scenario planning mode*.

Near Real-Time Mode: After most disastrous earthquakes, the extent of losses does not become fully known during the first few days because information from devastated areas does not flow freely, especially in difficult to access mountain areas. Even then, eyewitness reports are often confusing. Therefore, rapid and reliable estimates of likely losses, based on model calculations and teleseismic information, are essential for adequate and timely rescue and recovery operations. The ICES Foundation QLARM loss estimate facility is designed to address this situation. Loss estimates by QLARM are available within 30 minutes of significant earthquakes worldwide (Wyss, 2014) and include mean damage state, number of injured and number of fatalities for each settlement, and the sum of the human losses.

Before such losses can be estimated however, accurate information on the parameters of the earthquake in question must become available. For countries without dense high-quality seismograph networks, the source parameters have to be derived from global data. The earthquake parameters required for estimating event consequences are the hypocenters and the magnitude details.

Because of the distances between seismographs in the worldwide network, the travel time for seismic waves to reach a sufficient number of stations to allow a stable estimate of source parameters is about 10–15 minutes. Approximate source parameters become available by email after this delay. Only then, can the QLARM system commence preparations for loss estimates.

Given the location and magnitude of an earthquake, the QLARM system calculates intensity of shaking at the appropriate distance for every settlement in the database. Then the probability of all five damage grades is calculated for each of the building classes according to the respective fragility curves. In a third step, the number of fatalities and injured in three severity classes is calculated using a casualty matrix. It is necessary to include information on the current quality of building stock, soil properties, and present populations for these calculations to be accurate.

The moment tensor solutions distributed by the USGS, or others, can be of considerable help in refining QLARM loss estimates, especially if they also include estimates of rupture direction and fault finiteness. Improving the speed and quantity of moment tensor messages, together with the inclusion of identification of the fault plane and adding fault finiteness estimates, may well be one of the most useful additions for refining QLARM loss estimates in countries without dense local seismograph networks – such as in the countries addressed by this proposal.

It would be very desirable if more local and regional seismograph networks were able to electronically distribute high-quality calculations of earthquake epicenters in real time, especially depths, because this would cut about 10 minutes from analysis delays. The weakest parameter in teleseismic earthquake hypocenter data is the depth of the energy release. This parameter is of crucial importance because the damage caused at the Earth's surface decreases rapidly with increasing depth of the earthquake. The magnitude of hypocentral errors (approximately 15 km for USGS teleseismic locations), could be reduced by a factor of 3 to 4, with good local data availability. This in turn could influence the estimate of the number of fatalities in some cases by a factor of 10. Although we are currently able to correctly separate disastrous earthquakes from non-consequential ones in over 90% of the cases, input from well-run regional and local seismograph networks could strongly improve the accuracy of QLARM loss estimates in near real-time mode.

Application of satellite images to loss quantification: Direct inspection of satellite photographs of the damage to the built environment immediately after an earthquake can significantly contribute to real-time loss estimates. The effective use of satellite imagery (e.g. Huyck et al., 2014; Taubenboek et al., 2014) requires that a satellite pass over the affected area, that the earthquake has occurred during daytime, and that clouds are not obstructing the view from space. Additional methods to quantitatively estimate the degree of damage to buildings and to derive from this the approximate number of injured should be developed.

On the basis of satellite images, 3D models of cities can be developed, with the height of every building calculated from its shadow. On the basis of height, an approximate assignment of buildings to one or two groups of a given fragility class is possible. The fragility (inability to withstand shaking) is given as a probability that a building may sustain a certain degree of damage (e.g. collapse) as a function of intensity of ground shaking. From images of the Tandem InSAR mission the height of buildings can measured to 3m accuracy, which is to within one floor height of a building.

Creation of a local encyclopedia of soil conditions: Knowing the local soil conditions is important for estimating losses because these conditions can lead to amplifications of the ground accelerations by factors of 2 or more (e.g. Parvez and Rosset, 2014). However, reports on local conditions, including microzonation studies, are scattered in the literature (sometimes restricted to grey literature), and not generally known. Therefore, a collection of relevant information is needed. Alternatively, it may be possible to reach satisfactory approximations of the local enhancement of strong ground motion using surface topography [*Wald et al*., 2004].

The data sets in QLARM contain name, coordinates, estimated population, and a model for the vulnerability of buildings for about 2 million settlements worldwide. These data are used for peaceful purposes only.

China is the country leading the world at this time in earthquake fatalities and injured because of three combined factors: Great earthquakes, a large population and weak buildings in some regions. Many of the disastrous earthquakes in China occur in mountainous areas where communications and access are especially difficult. For example, in the Wenchuan magnitude 8 earthquake of 12 May 2008, approximately 85,000 people were killed, but the responsible Chinese agency believed for several days that the fatalities only numbered about 5% of this. On the other hand, Figure 1 shows that the QLARM calculation assessed the Wenchuan earthquake disaster correctly many days before officials realized the extent of the calamity.

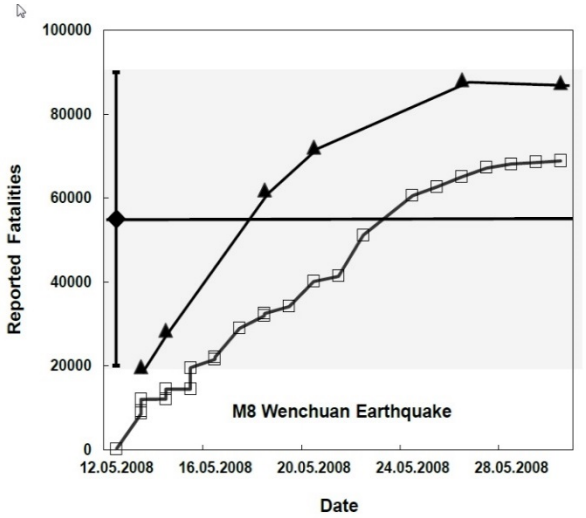

Figure 1: Fatalities (open squares) and the sum of fatalities plus missing (solid triangles) as a function of the date after the Wenchuan M8 earthquake 2009, as reported by the Chinese News Agency, compared to the estimate by the QLARM team 100 minutes after the disaster (diamond), with its uncertainty (vertical bar). This early estimate was performed with input from a Chinese colleague who believed the magnitude was 8 not 7.5 as first reported in the west.

Using the QLARM loss estimate system in scenario planning mode. Estimating losses before they have occurred will allow authorities to plan for, prepare and mitigate the future consequences as much as possible regarding what will happen eventually along these plate boundaries. After the events occur, it also affords an opportunity to compare the calculations with reality.

It is certainly disconcerting to calculate the numbers of fatalities and injured in future earthquakes because grim pictures result, and because such estimates are subject to many assumptions. Nevertheless, uncertain as these estimates may be, one must attempt to make them, as best one can. The motivation for such studies is to provide a quantitative basis for setting priorities in mitigation efforts and to prepare for the realistic scale of a likely disaster. Although the exact time of future earthquakes is unknown, there is no doubt that magnitude eight classes earthquakes will happen along the front of the Himalaya. The forces of plate tectonics that cause India to collide with Asia, thrusting up the most magnificent mountain chain on the planet, continue to generate great earthquakes in this collision zone (e.g. Bilham, 2006; 2014).

Quantitative estimates of potential losses caused by future great earthquakes along the Himalaya (Wyss, 2005) suggest that as many as 150,000 people may die, 300,000 may be injured and typically 3,000 settlements will be affected in single events. Scenario mode results used here vary and are based on ruptures of 150 km segments of the plate boundary at seven positions, where sufficient elastic energy is believed to be stored for magnitude eight earthquakes. The method of calculating these results was calibrated using the 17 disastrous Indian earthquakes that have occurred since 1980. About 50 settlements in the region are considered most at risk because in each settlement more than 2000 fatalities are calculated to occur.

Of the seven scenarios proposed in March by Wyss (2005), two have come true. In October 2005 the Kashmir M7.6 earthquake caused about 85,000 deaths, as Wyss had predicted (Wyss, 2006). In April 2015 the M7.6 Ghorka earthquake killed about half as many as Wyss (2005) had estimated in his Nepal scenario (Wyss, 2016).

The QLARM data sets and loss calculation system have proven very well calibrated for China. This is demonstrated by the retrospective calculation of the probable losses in the Haicheng, M7.3, 1975 earthquake, had no evacuation taken place. Wyss and Wu (2014) estimate that about 8,000 fatalities and 27,000 injuries were avoided. Quantitative estimates of losses by QLARM in future earthquakes in China and the Himalayas can therefore be of real use in reducing human suffering in the study area.

Together with Chinese, Indian and Nepalese expert seismologists The ICES Foundation will design scenario mode loss estimates for extended faulting in large earthquakes along faults that these experts deem likely to rupture.

Finally, and in addition, the data set in the QLARM system regarding settlements can be used to estimate losses due to calamities and disasters wrought by flooding, land slides and fires that are becoming more frequent in the Himalaya due to land-use change and global climate change.

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Press Release 2 September 2015

LASG/IAP and ICES sign collaboration agreement for the Himalayan Region and establishment of Asian Centre for Earth System Simulation

Mountains are among the regions that are most sensitive to climate change and to the impacts of human activities. The Himalayan Region, characterized by the massive mountain ranges of the Himalaya, has therefore attracted wide research interest. The State Key Laboratory of Numerical Modelling for Atmospheric Sciences and Geophysical Fluid Dynamics (LASG), Institute of Atmospheric Physics (IAP), Chinese Academy of Sciences (CAS) signed a cooperation agreement with the International Centre for Earth Simulation (ICES) Foundation on 19 August, 2015 to boost research on the dynamics of the Himalayan Region. Following the agreement, an Asian Centre for Earth System Simulation (ACESS) will be established.

ICES Foundation is a Geneva-based, not-for-profit organization and the Himalaya Project is a major element in its global vision and mission. LASG/IAP has been devoted to Tibetan Plateau research since 1980s, including its impact on monsoons and climate. Both parties have agreed to collaborate and to share expertise and knowledge with ACESS such that they build value and working experience in matters relating to the Himalayan Region and its impact on weather, climate, geological, biological and socioeconomic factors throughout Asia and the rest of the world - with focus on data visualization, climate modeling, water & energy resources, and disaster risk reduction. At present the ACESS International Project Office (IPO) is located in LASG/IAP.

LASG/IAP/CAS will be primarily responsible for carrying out research and development projects in China and for leveraging its local knowledge, contacts and expertise. The responsibilities of ICES include advising ACESS in the use of advanced digital visualization techniques and implementing quality control systems of an international standard while assisting ACESS to collaborate with other members of the ICES community.

Director-General of IAP/CAS Prof. ZHU Jiang, wished the cooperation could take full advantage of both parties' strength and develop new climate system insights for the Himalaya Project. One of four advisors of the IPO and also a CAS academician, Prof. WU Guoxiong commented that, "The signing of the project and inauguration of ACESS is a continuation of the successful collaboration between LASG/IAP and ICES as well as other international agencies in the previous stages of Tibetan Plateau research. Formation of ACESS signals a new phase of cooperation in the field".

Dr. Robert Bishop, President & Founder of ICES indicated the importance of Himalaya and Tibetan Plateau dynamics to the entire world system and that this partnership would shed new light on the extent of their global impact.

Background:

LASG/IAP was founded in 1985 and its priority research areas include: (I) Earth System model development and application, (II) weather and climate dynamics, (III) the predictability of weather and climate, and (IV) geophysical fluid dynamics. http://www.lasg.ac.cn/

ICES is a non-profit organisation whose mission is to collate and integrate global pools of knowledge from across scientific and socio-economic disciplines and develop holistic modelling and simulation to predict the future directions and scenarios of various Earth Systems, especially those affecting climate change, extreme weather, geoengineering, resource depletion, fresh water availability, food security, public health and safety, and hazard reduction and mitigation. http://www.icesfoundation.org

"The Himalaya Project" has been conceived by ICES to improve communication and collaboration among governments, academic and commercial organizations in the 16 nations that are either bordering, exercising jurisdiction or directly impacted by events occurring in the Himalayan Region, so as to produce a unified knowledge system of the region. Such a unified knowledge system (UKS) will collate and process various data to help assess the regional and global impact of human behaviour within the area as well as to help mitigate the occurrence of natural disasters. At the same time, the UKS will help in the design and maintenance of a thriving ecological civilization throughout the region.

Key presentation material available from the various Key State Laboratories of the Chinese Academy of Sciences:

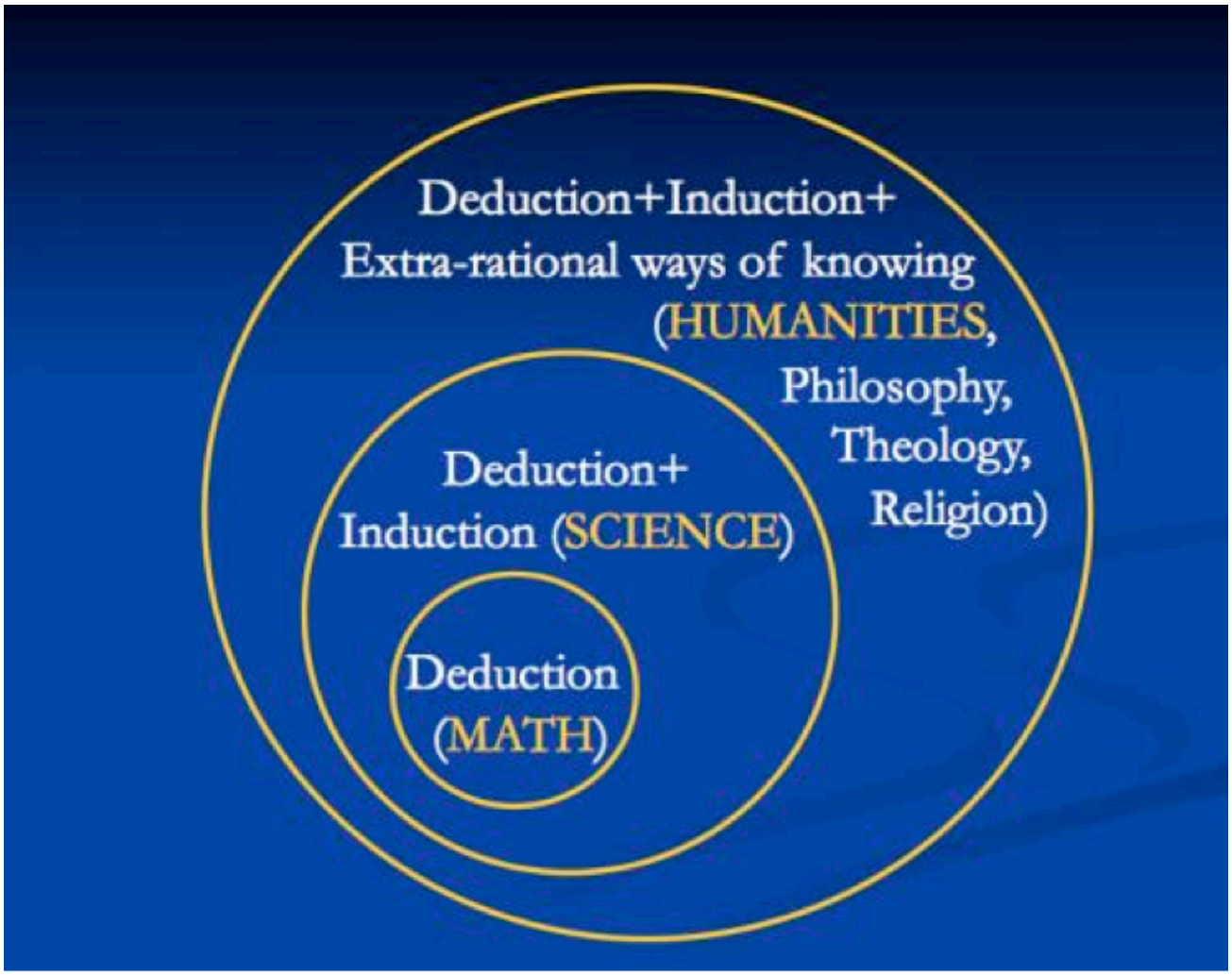
Introduction to LASG/IAP/CAS: ***L***aboratory for ***A***tmospheric ***S***ciences & ***G***eophysical fluid dynamics

Himalayas Climate Modeling: development of a high-resolution Earth System Model and Asian climate change risk assessment

Variation in the Coupled Land-Atmosphere System over the Tibetan Plateau and its global climate impact

Land Surface Hydrology Modeling

High Resolution Ocean Model and Coupled Model at LASG/IAP/CAS


Deduction+Induction+
Extra-rational ways of knowing
(HUMANITIES,
Philosophy,
Theology,
Religion)
Deduction+
Induction (SCIENCE)
Deduction
(MATH)

APPENDIX A (films, videos & written materials)

The following films & videos introduce the key role played by the Himalayan Mountains:

Himalayas: water towers of Asia
http://www.bbc.com/future/story/20130122-himalayas-water-towers-of-asia
Mount Everest: how it was made
http://www.youtube.com/watch?v=KnE6S_Mb-mY
K2: climbing the world's highest mountain (part 2)
http://www.youtube.com/watch?v=HgVryHjBmxY
Pakistani Kashmir turns to water to solve power crisis
http://www.youtube.com/watch?v=Rxf9MDRQZaU
BBC: Our World – India's water crisis
http://www.youtube.com/watch?v=jscOuWpw_iU
The Roots of India's Water Crisis
http://www.youtube.com/watch?v=x8kqq1f14vg
The Tipping Points: India Water Crisis
http://www.sbs.com.au/ondemand/video/218607171939
Climate change will increase flow in Asia's big rivers
http://www.scidev.net/south-asia/environment/news/climate-change-will-increase-flow-in-asia-s-big-rivers.html

The following articles describe the dynamics and impact of the Asian Monsoon system:

Impact of cloud radiative heating on East Asian summer monsoon circulation
http://iopscience.iop.org/1748-9326/10/7/074014/pdf/1748-9326_10_7_074014.pdf
Multi-scale drought and ocean-atmosphere variability in monsoon Asia
http://iopscience.iop.org/1748-9326/10/7/074010/pdf/1748-9326_10_7_074010.pdf
Weather forecasting: traditional knowledge of the people of Uttarakhand Himalaya
http://midimar.gov.rw/uploads/tx_download/National_Risk_Atlas_of_Rwanda_electronic_version.pdf

The following articles describe incoming global impacts to the Himalaya Region:

Arctic moisture source for Eurasian snow cover variations in autumn
http://iopscience.iop.org/1748-9326/10/5/054015/pdf/1748-9326_10_5_054015.pdf
Substantial glacier ice loss in Central Asia's largest mountain range
http://www.gfz-potsdam.de/en/media-communication/press-releases/details/article/erheblicher-gletscherschwund-in-zentralasiens-groesster-gebirgskette/
Making the Northern Indian Ocean a hub of geomagnetic data
https://eos.org/project-updates/making-the-northern-indian-ocean-a-hub-of-geomagnetic-data

The following articles describe glacier dynamics within the Himalayan Mountains:

Glacier changes at the top of the world – over 70% of glacier volume in Everest could be lost by 2100
http://www.egu.eu/news/164/glacier-changes-at-the-top-of-the-world-over-70-of-glacier-volume-in-everest-region-could-be-lost-by-2100/
Modelling glacier change in the Everest region, Nepal Himalaya
http://www.the-cryosphere.net/9/1105/2015/tc-9-1105-2015.pdf
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http://www.trust.org/item/20150909073825-39czr/

The Nepali Chapter

A full description of the Nepal earthquake of April 25, 2015 can be found at the following URL:
http://www.icesfoundation.org/Pages/CustomPage.aspx?ID=133
Strategic framework for resilient livelihoods in earthquake-affected areas of Nepal
http://lib.icimod.org/record/30799/files/ICIMOD_WP_15.6.pdf
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http://www.acted.org/fr/node/11431
Agricultural livelihood earthquake impact appraisal in 6 most affected districts
http://foodsecuritycluster.net/sites/default/files/Nepal%20ALIA%20-%20Agricultural%20Livelihoods%20Impact%20Appraisal%20-%20June%2006_0.pdf
Understanding the role of remittances in reducing earthquake risk
http://un.org.np/sites/default/files/understand-role-remittances.pdf
A comparative assessment of school safety after the Nepal earthquakes of 2015
http://lib.icimod.org/record/30799/files/ICIMOD_WP_15.6.pdf
Glacier status in Nepal and decadal change from 1980-2010 based on Landsat data
http://lib.icimod.org/record/29591/files/GSN-RR14-2.pdf
Nepal landslide deaths highlight disaster risk reduction gaps
http://www.irinnews.org/report/100451/nepal-landslide-deaths-highlight-disaster-risk-reduction-gaps
Nepal's disaster preparedness woefully inadequate
http://www.myrepublica.com/portal/index.php?action=news_details&news_id=81437
An unseen reality – recovery following small disasters in remote areas – the case of Sannighat, Nepal
http://www.preventionweb.net/files/41754_41754unseenrealityrecoveryofremotec.pdf
Impacts of climate change on hydrological regime and water resources management of the Koshi River Basin
http://www.sciencedirect.com/science/article/pii/S2214581815000889
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What we can learn from the August 2014 Karnali River floods
http://knowledge.zurich.com/wp-content/uploads/2015/07/risk-nexus-karnali-river-floods-nepal-july-2015.pdf
Adapting to climate change for sustainable agribusiness in high mountain watersheds – case study Nepal
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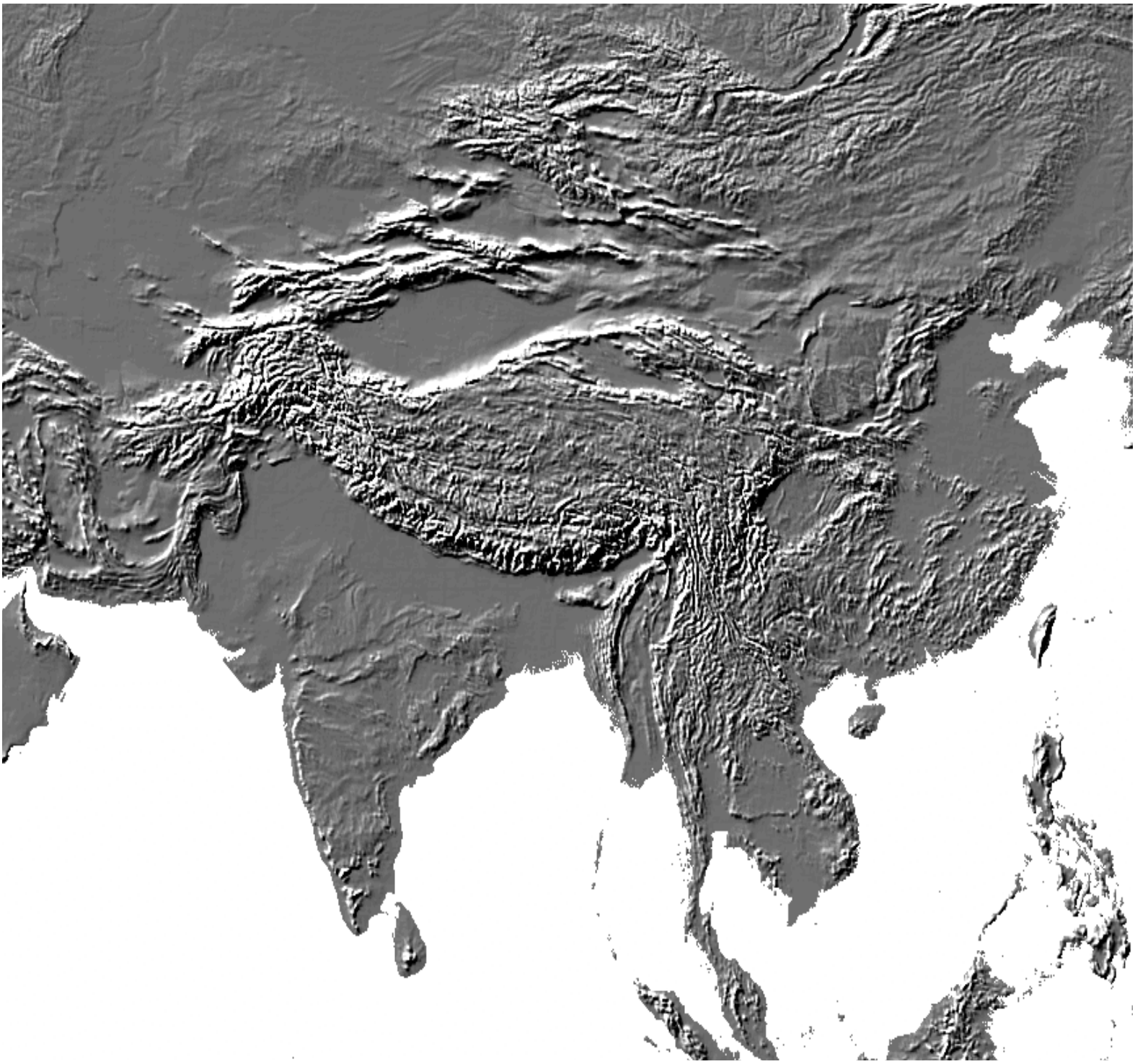
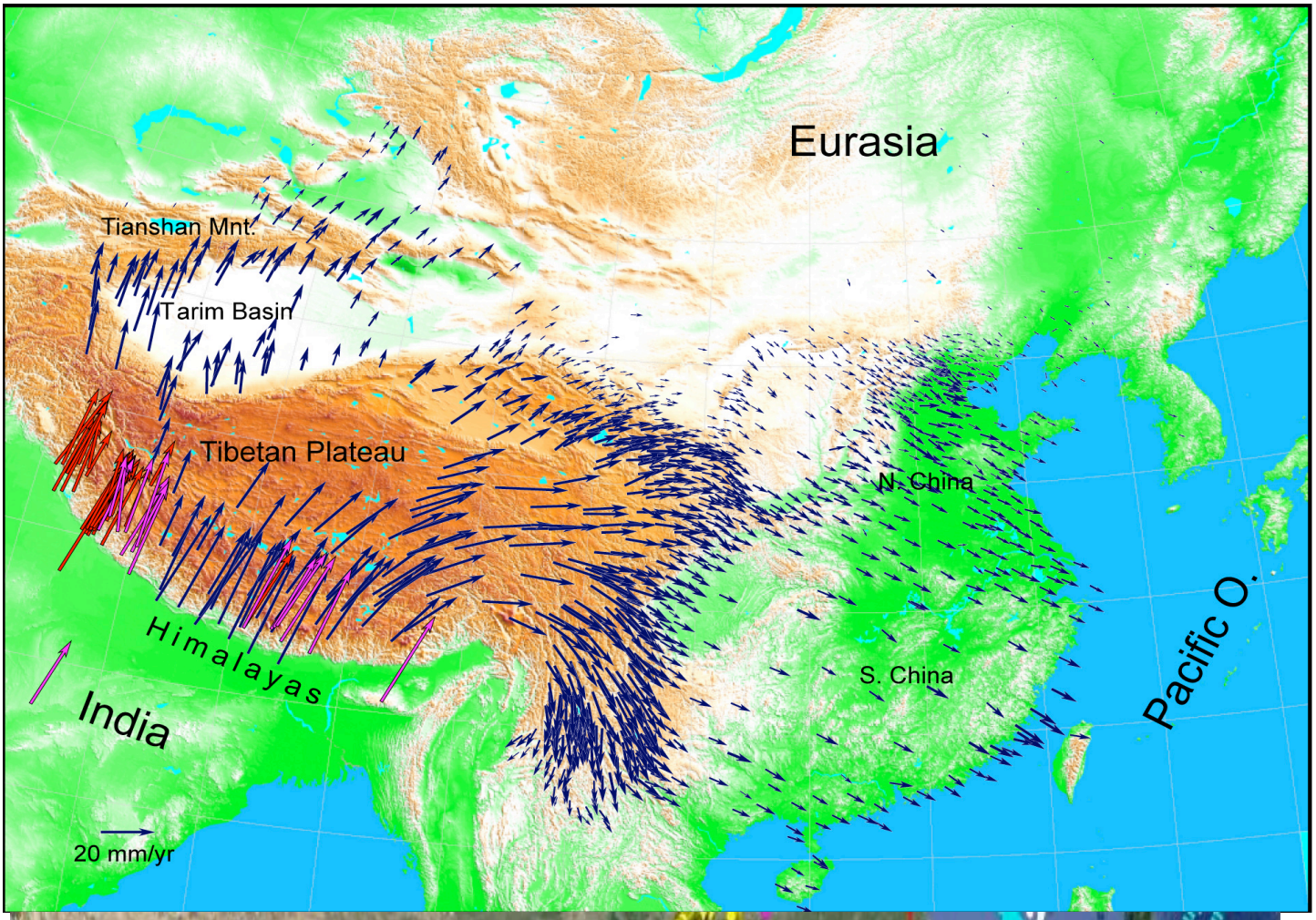
Re-thinking climate interventions in fragile and conflict-affected states: insights from Nepal
http://www.newsecuritybeat.org/2015/02/re-thinking-climate-interventions-fragile-conflict-affected-states-insights-nepal/
Multi-decadal mass loss of glaciers in the Everest area (Nepal Himalaya) derived from stereo imagery
http://www.the-cryosphere.net/5/349/2011/tc-5-349-2011.pdf
Strengthening livelihood capacities to DRR in Nepal
http://flagship4.nrrc.org.np/document/strengthening-livelihood-capacities-disaster-risk-reduction-nepal
Aid aims to help rice farmers in a warming world
http://www.climatenewsnetwork.net/aid-aims-help-rice-farmers-warming-world/
Nepal: preparing farmers for climate change
http://www.ekantipur.com.np/2014/11/25/development/preparing-farmers-for-climate-change/398140.html
After Nepal is Asia prepared for the 'big one'?
http://www.irinnews.org/fr/report/101902/after-nepal-is-south-asia-prepared-for-the-big-one

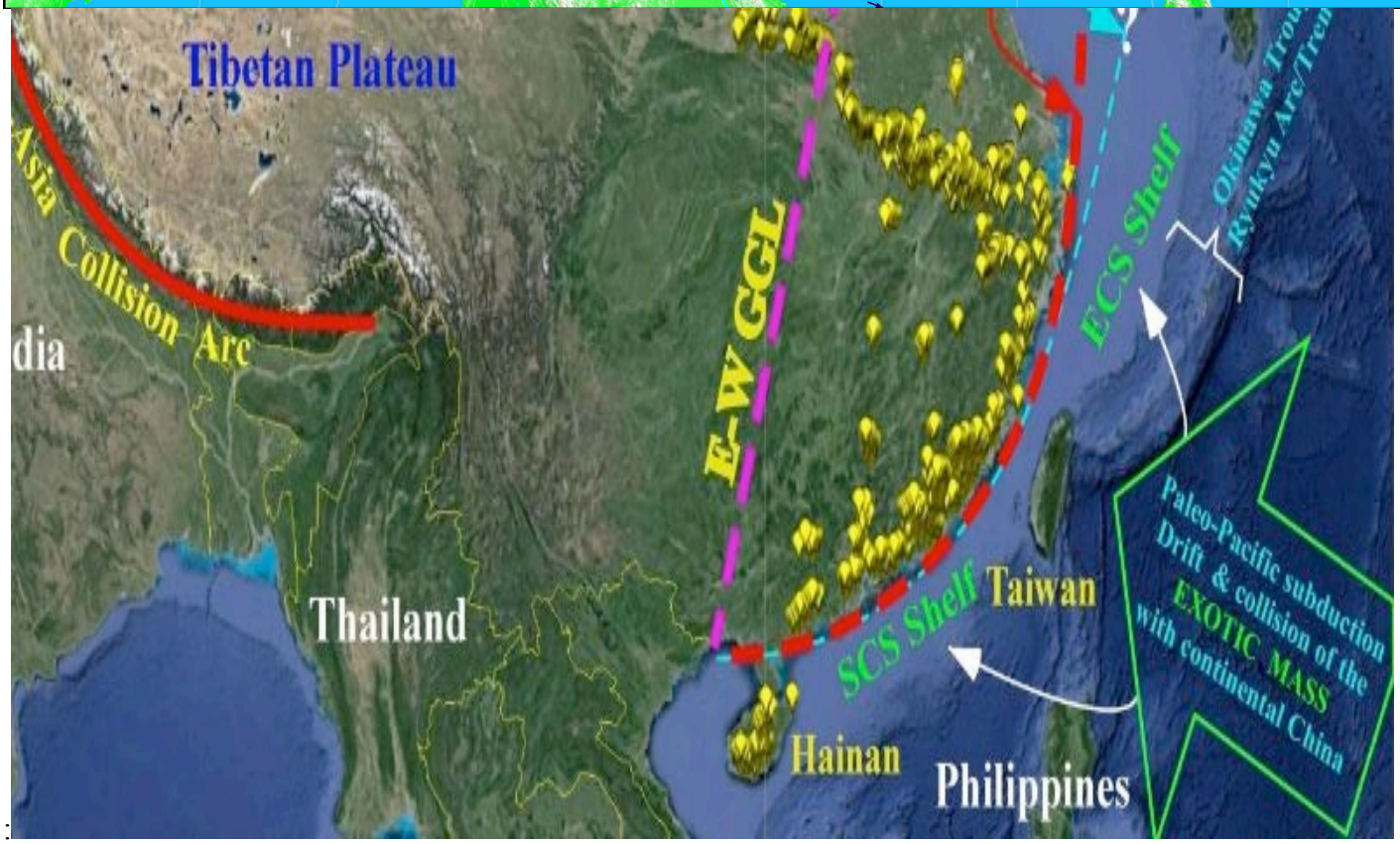
The following articles describe the trans-boundary political dynamics of the Region:

The Silent War made by India in Bangladesh
http://www.youtube.com/watch?v=jYYxCwk8thU
India woos neighbours as rifts open doors to China
http://tribune.com.pk/story/798634/india-woos-neighbours-as-rifts-open-door-to-china/
What China has been building in the South China Sea
http://www.nytimes.com/interactive/2015/07/30/world/asia/what-china-has-been-building-in-the-south-china-sea.html?hp&action=click&pgtype=Homepage&module=photo-spot-region&region=top-news&WT.nav=top-news
A critical disconnect: the role of SAARC in building the DRM capacities of South Asian countries
http://www.brookings.edu/~/media/research/files/papers/2015/05/05-south-asia-distasters-white/role-of-saarc-in-drm-south-asia-may-5-2015.pdf
Built on sand: Singapore and the new state of risk
http://www.harvarddesignmagazine.org/issues/39/built-on-sand-singapore-and-the-new-state-of-risk
Tools for culture design: toward a science of social change
http://www.spanda.org/SpandaJounrnal_VI,1.pdf
Resilient rice
http://www.povertyactionlab.org/publication/resilient-rice

APPENDIX B (Topology & Tectonics)




Eurasia
Tianshan Mnt.
Tarim Basin
Tibetan Plateau
N. China
S. China
Pacific O.
Himalayas
India
20 mm/yr


Tibetan Plateau
Asia Collision Arc
dia
E-W GGL
ECS Shelf
Okinawa Trou
Ryukyu Arc/Tren
Thailand
SCS Shelf
Taiwan
Paleo-Pacific subduction
Drift & collision of the
EXOTIC MASS
with continental China
Hainan
Philippines