Observations for testing model processes

Does increasing model resolution facilitate a deeper level of model - processes evaluation?

Depends on the process but definitely yes for moist physical processes.

Graeme Stephens
Cal. Institute of Technology, JPL
& Uni of Reading
Co-chair of GEWEX

Outline

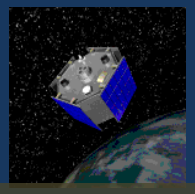
- EO background
- Two examples of process evaluation
- GEWEX GC & PROES
- PRIMAVERA process evaluation focus?

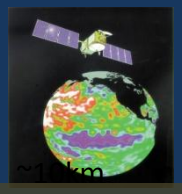
We have a wide collection of EOs teaching us much about the Earth 'system' as it operates today….

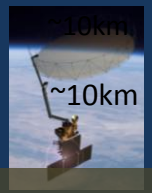
JPL Earth Science Flight Projects

Operational


Rapdscat (2014)

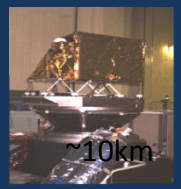

ACRIMSAT (1999)


Jason-1 (2001)



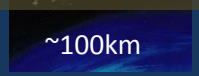
Soil Moisture SMAP (2014)

OCO-2 (2014)

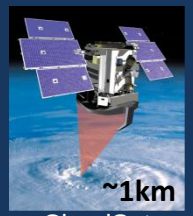


AIRS (2002))

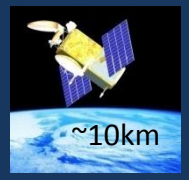
TES (2004)



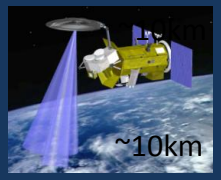
MLS (2004)



CloudSat (2006)

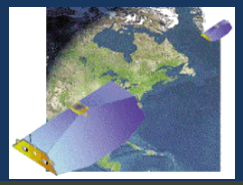


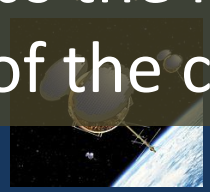
Ocean Surface Topography Mission (JASON-2; 2008)



Sea Surface Salinity: Aquarius (2011-2015)

Formulation/ Development


GRACE-FO (2017)


COSMIC-2* (2015+)

ECOSTRESS (2017)


SWOT (2019)

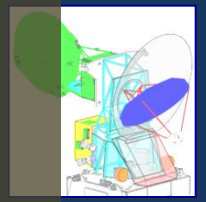

OCO-3 (NLT 2016)

Mission Studies/Concepts


CLARREO (2020)

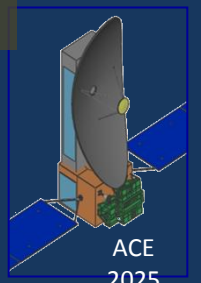

HyspIRI

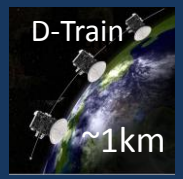

GEO-CAPE


Ocean Vector Winds

Ventures under review

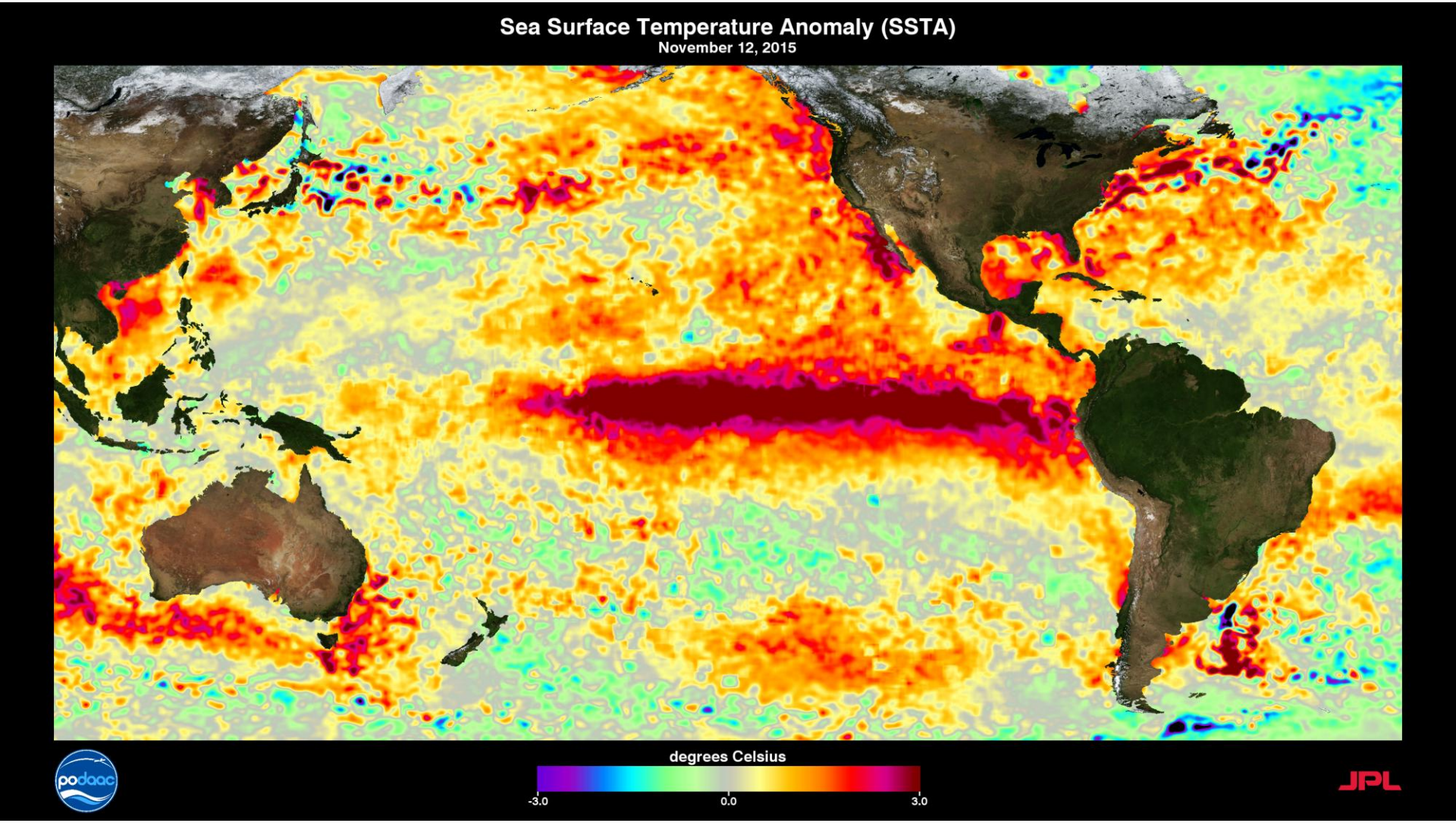
StormSat Doppler Radar on ISS


ACE 2025



One advantage of high resolution comes with use of observational 'simulators' the more the model resolution matches the intrinsic resolution of the obs the less ambiguous are the interpretation of the comparisons

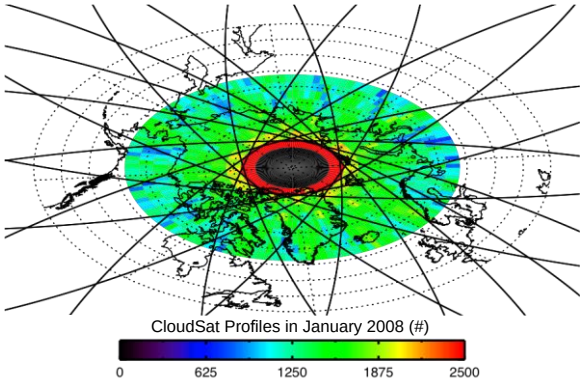
We are also developing data records on finer and finer scales, like SST @ 1km



And we are producing more integrated data records

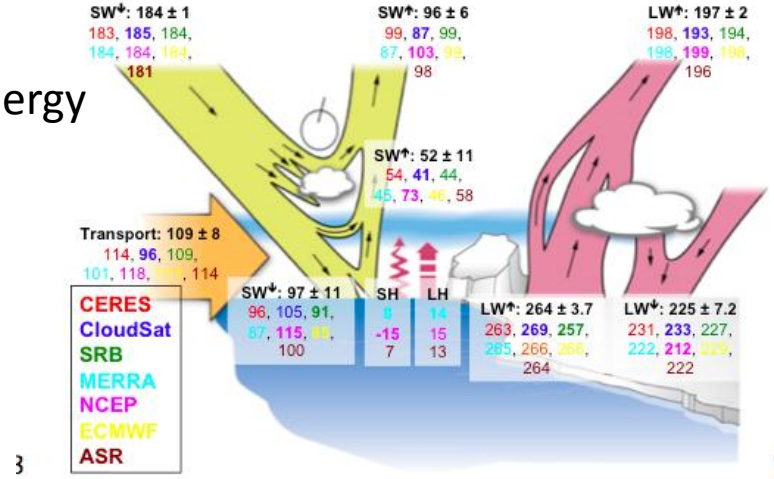
Arctic Observation and Reanalysis Integrated System: A New Data Product for Validation and Climate Study

Matthew W. Christensen[1,2], Ali Behrangi[2], and Graeme L. Stephens[2], Bull Amer Met Soc., 2016

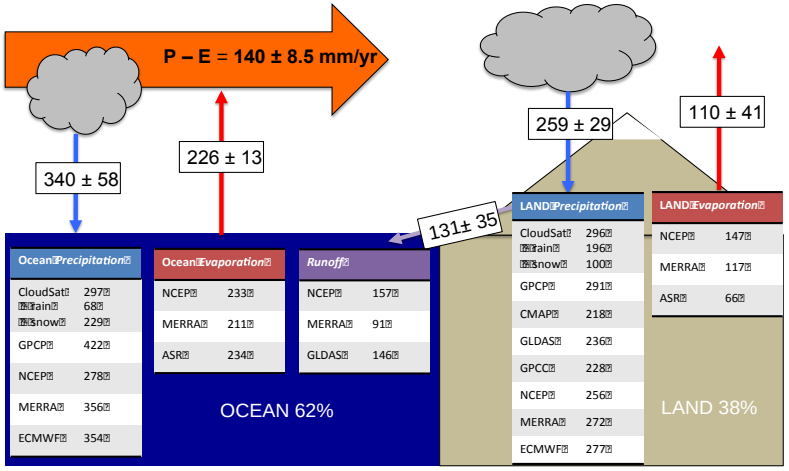


Multiple satellite, surface and reanalysis data sources are matched and gridded

Arctic energy balance

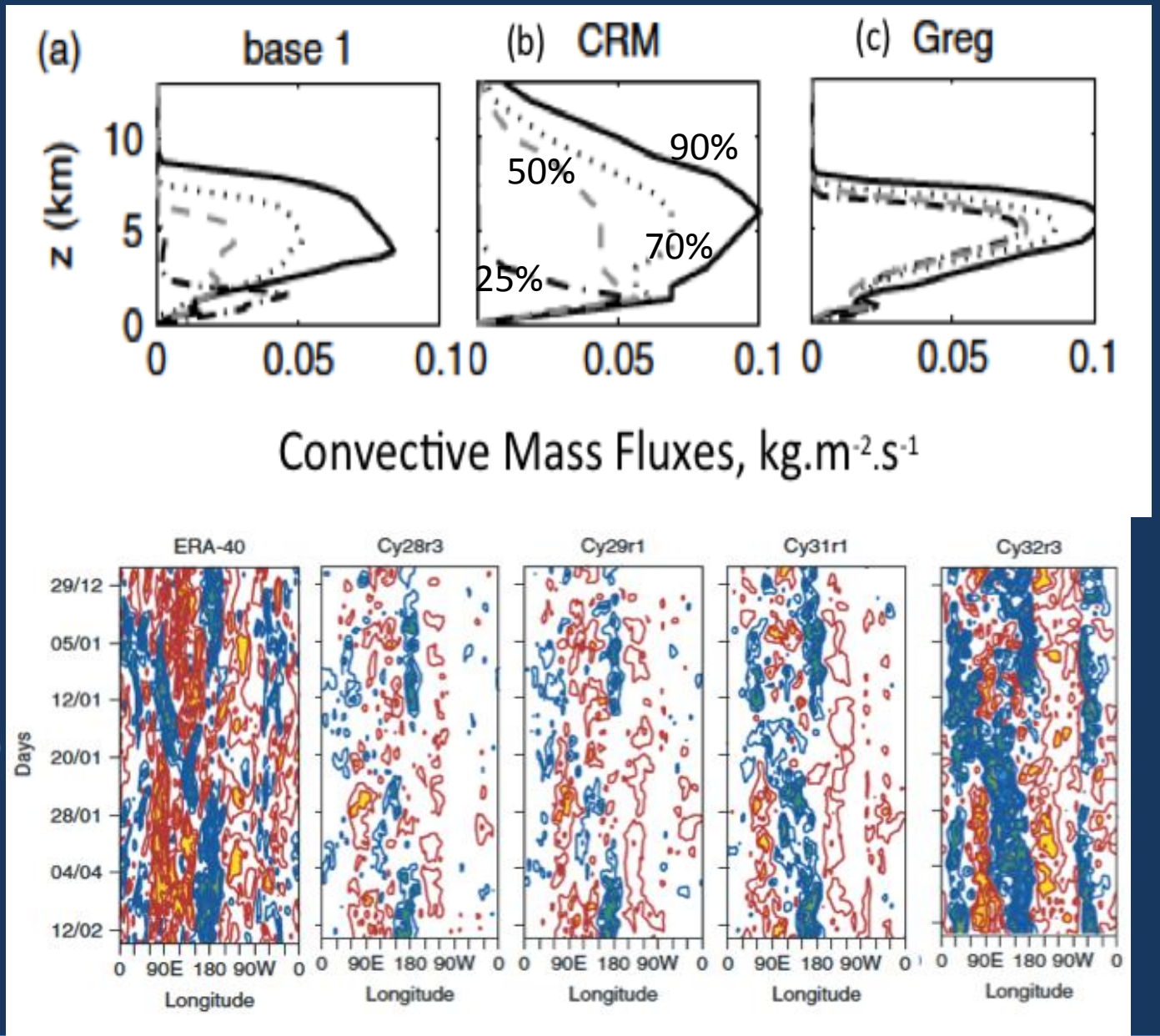


Arctic hydrological cycle



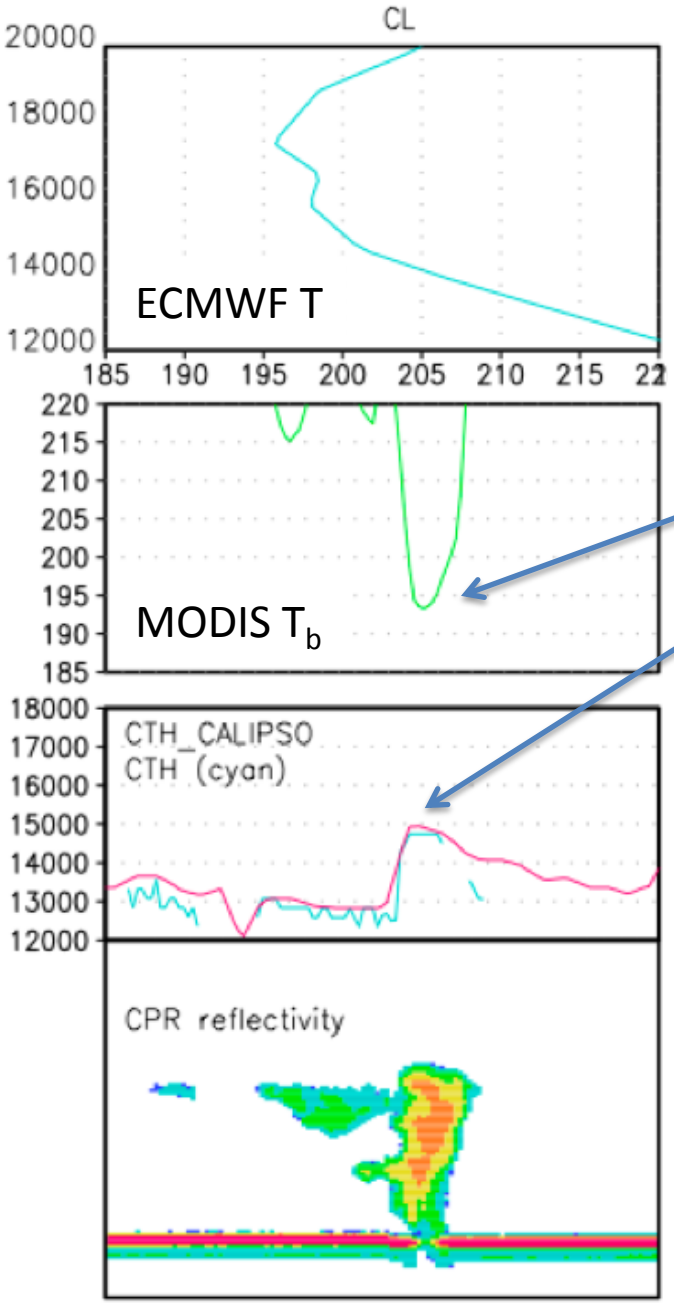
Processes 1) convection

The influence of water vapor on deep convection and convection organization.



Bechtold et al, 2008)

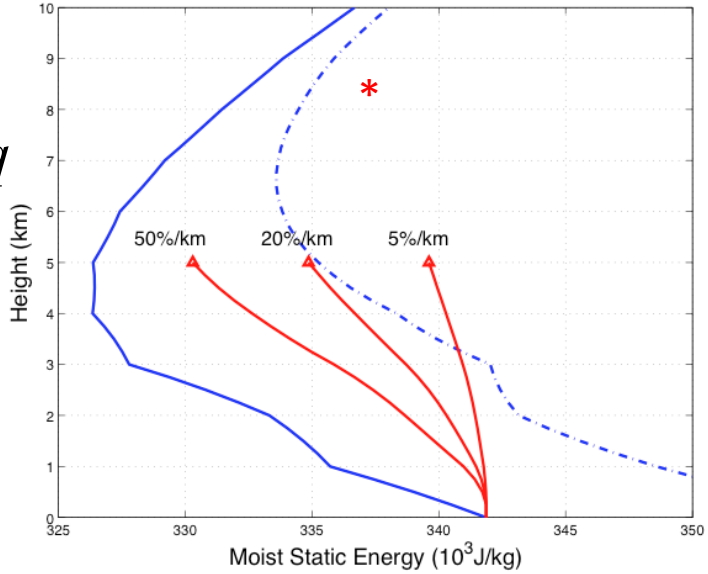
The convective process



Cloud-top MSE

$$C_p T + gz + L_v q$$

$$\frac{dF}{dz} = /(F' - F)$$

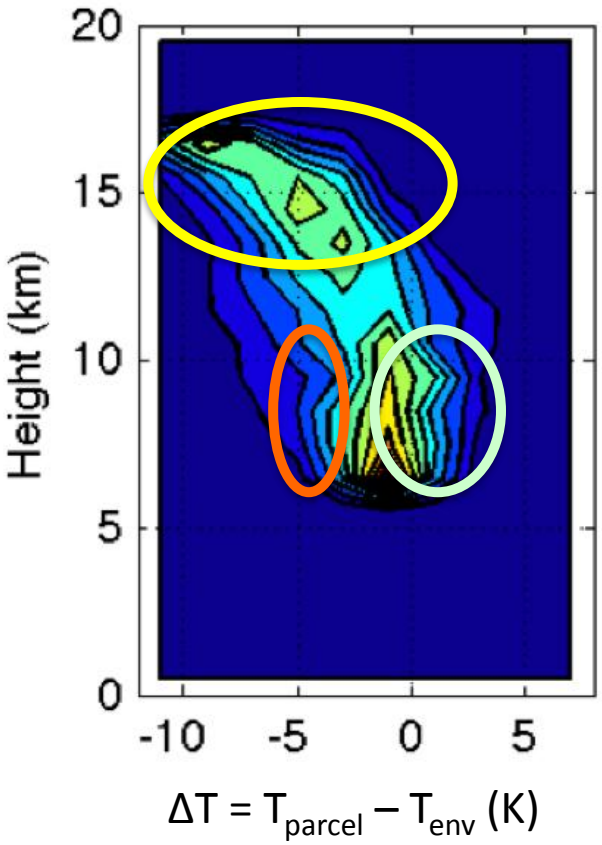


$$B \propto g\frac{T_{parcel} - T_{env}}{T_{env}}$$

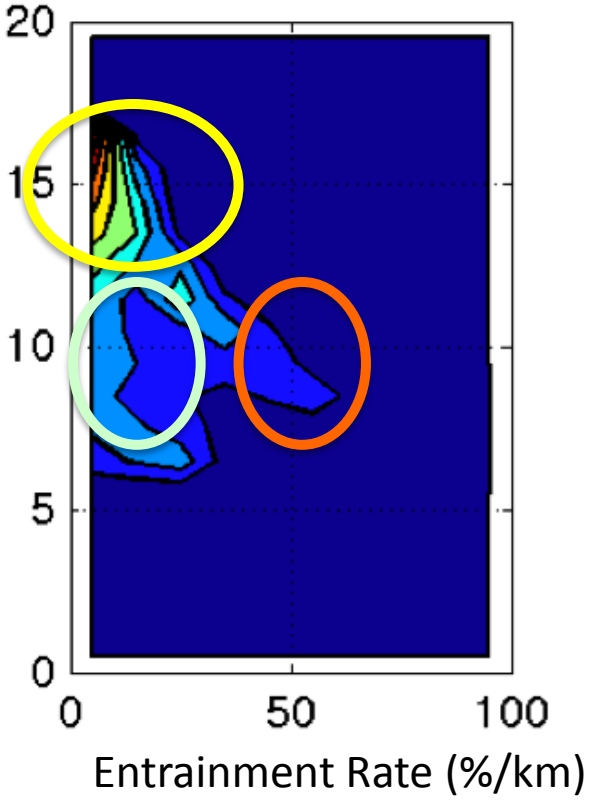
T_{parcel}=193 K; T_{env}=198 K

Negatively buoyant!

Buoyancy



Entrainment rate



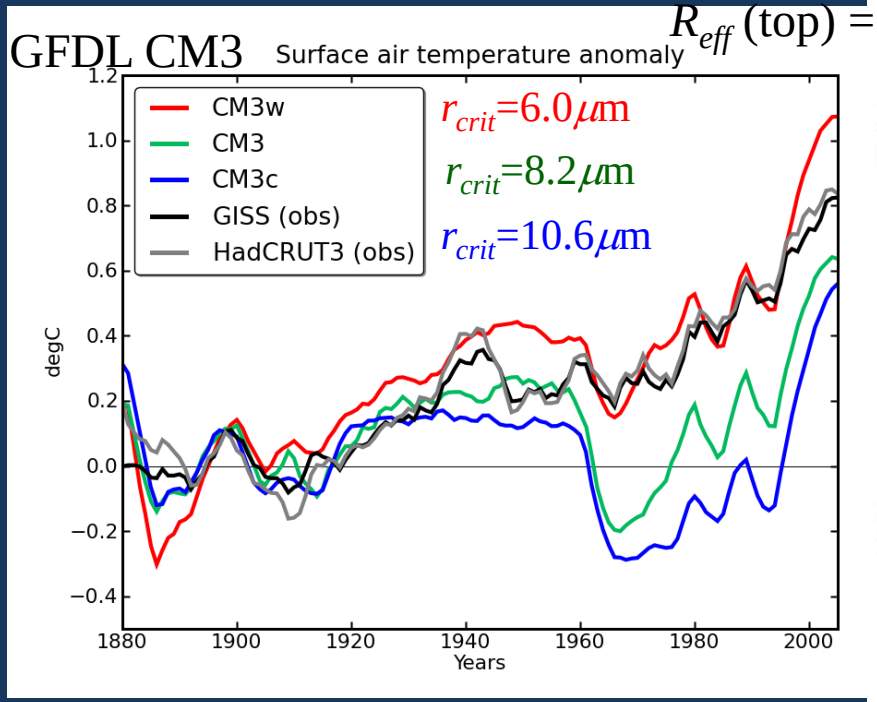
Deep convection:
B <0 & λ < 10%/km

"Terminal" cumulus congestus:
B < 0 & λ up to 50%/km

"Transient" cumulus congestus:
B > 0 & λ ~ 10%/km

Can we develop tests of the assumptions about environmental dependences of convection with approaches like this (UTCC PROES - later)?

Process evaluation 2) warm rain

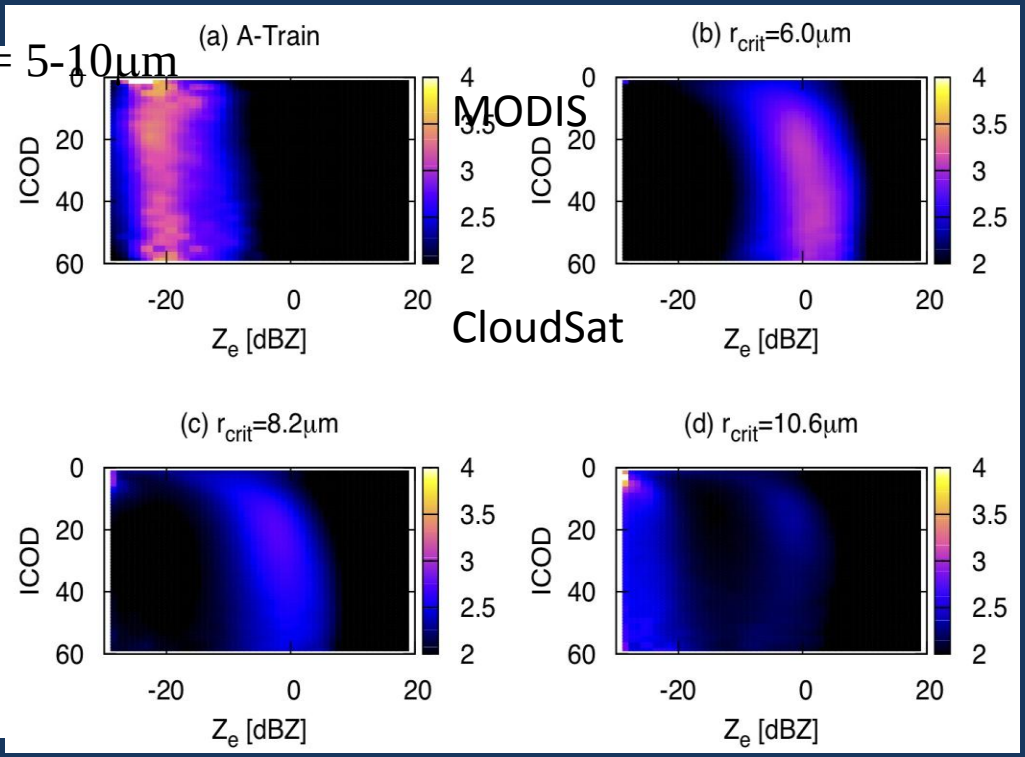


R_{eff} (top) = 5-10μm

r_{crit}=6.0μm

r_{crit}=8.2μm

r_{crit}=10.6μm



Golaz et al (2013)

- ✓ Historical temperature change simulations are sensitive to the details of how warm precipitation is triggered
- ✓ The most realistic warm rain initiation produces the *worst* simulation.
- ✓ Small changes in reflected energy appear to force a transition into a different regime that appears to be triggered by the Mt Agung eruption in early 1960s.

Grand Challenges

WCRP World Climate Research Programme

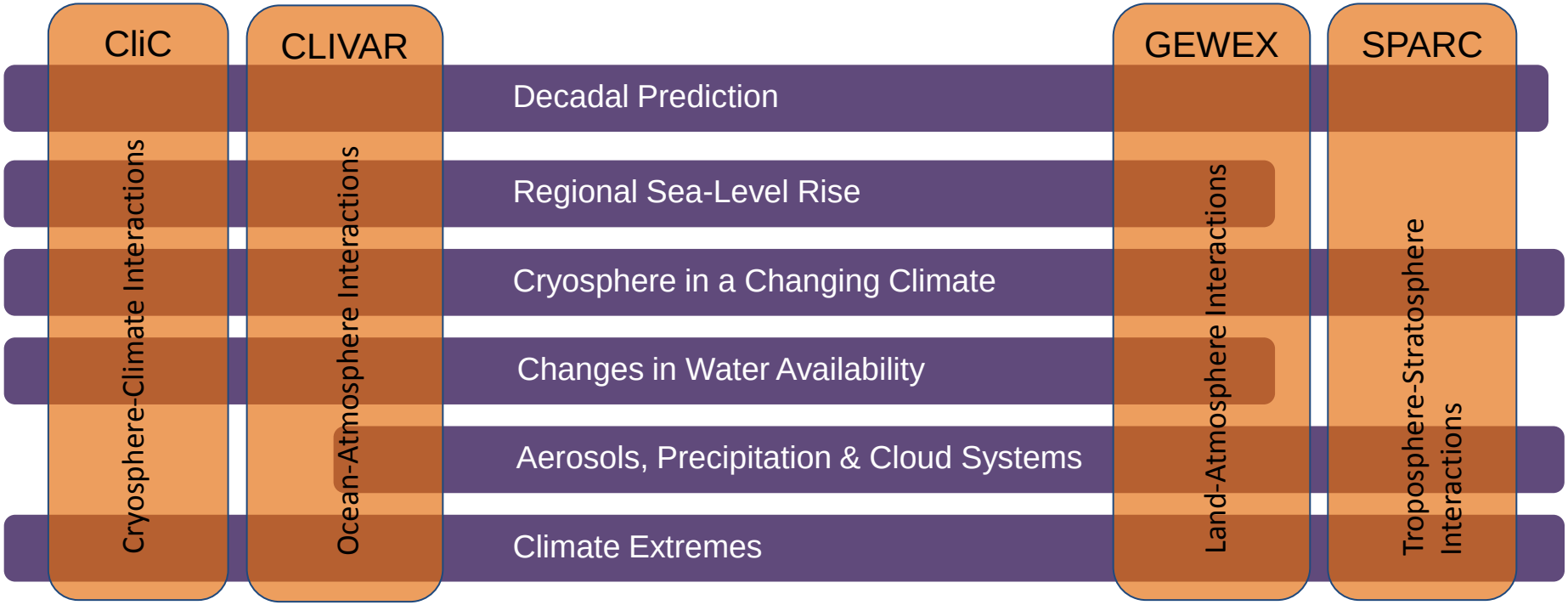
Joint Scientific Committee

Joint Planning Staff

Modeling Advisory Council

Data Advisory Council

Working Groups on: Couple Modeling (WGCM), Region Climate (WGRC), Seasonal to Interannual Prediction (WGSIP), Numerical Experimentation (WGNE)



Water Availability GC

- To what degree can we close the water balance today?
- How will the character of fresh water availability change in the coming decades?
- Can we be confident in predictions about how the water cycle will change in the future?

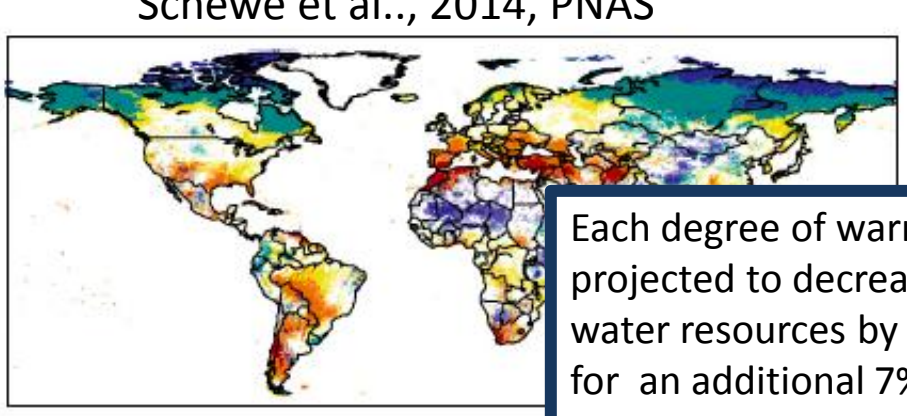
GEWEX Questions

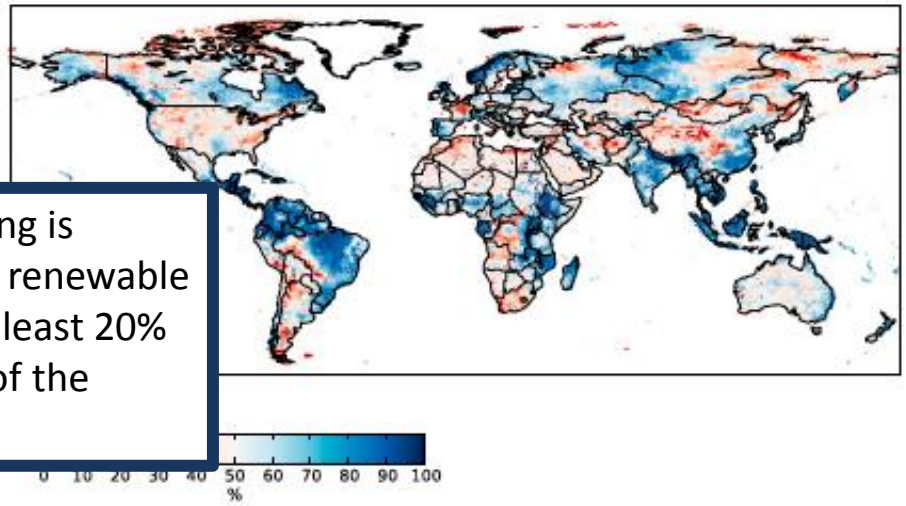
Q1: How can we better understand and predict precipitation variability and changes?

Q2: How do changes in the land surface and hydrology influence past and future changes in water availability and security?

Q3: How does a warming world affect climate extremes, and especially droughts, floods and heat waves, and how do land processes, in particular, contribute?

Schewe et al.., 2014, PNAS

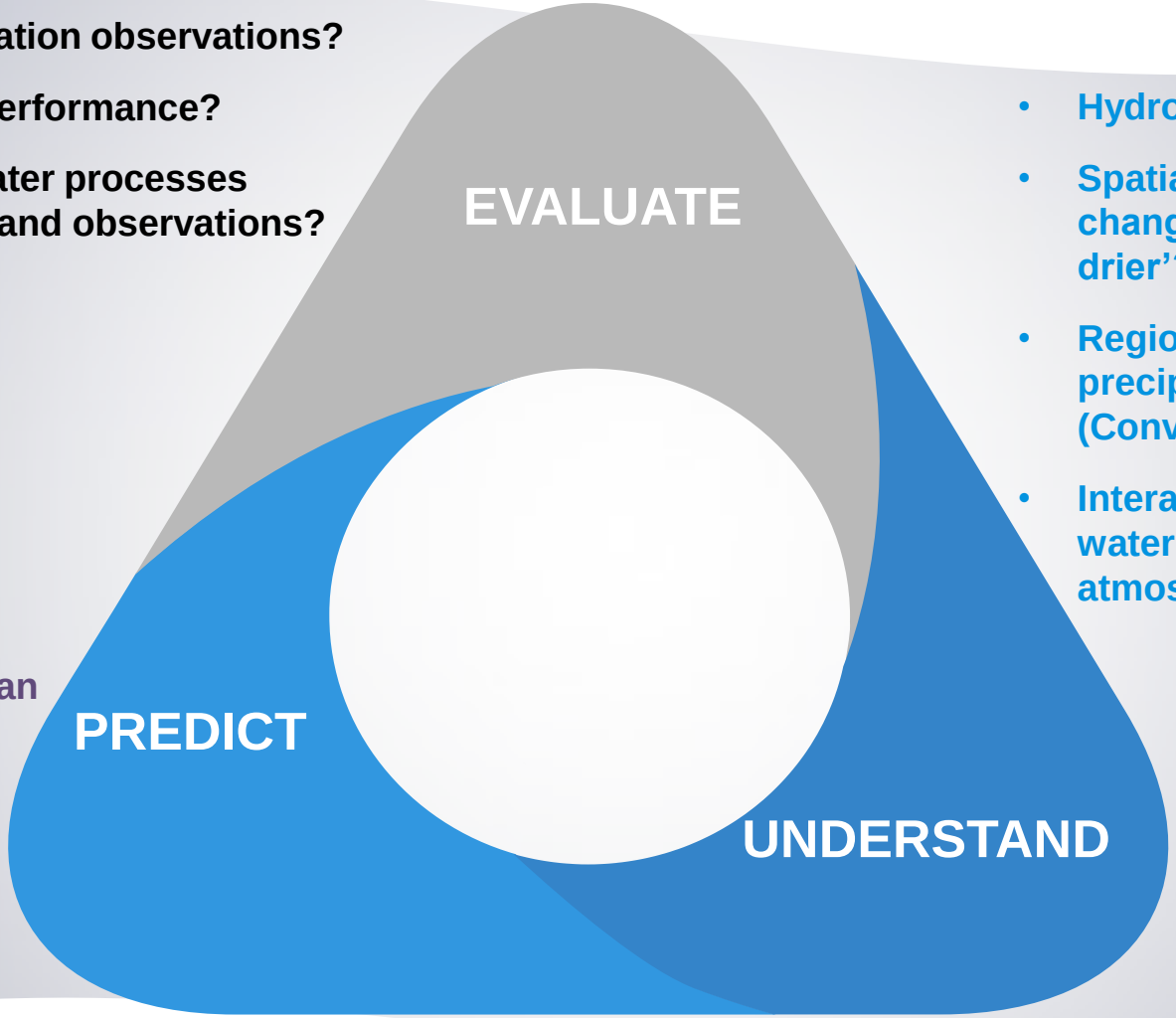




Each degree of warming is projected to decrease renewable water resources by at least 20% for an additional 7% of the global population.

Water Availability GC - Themes

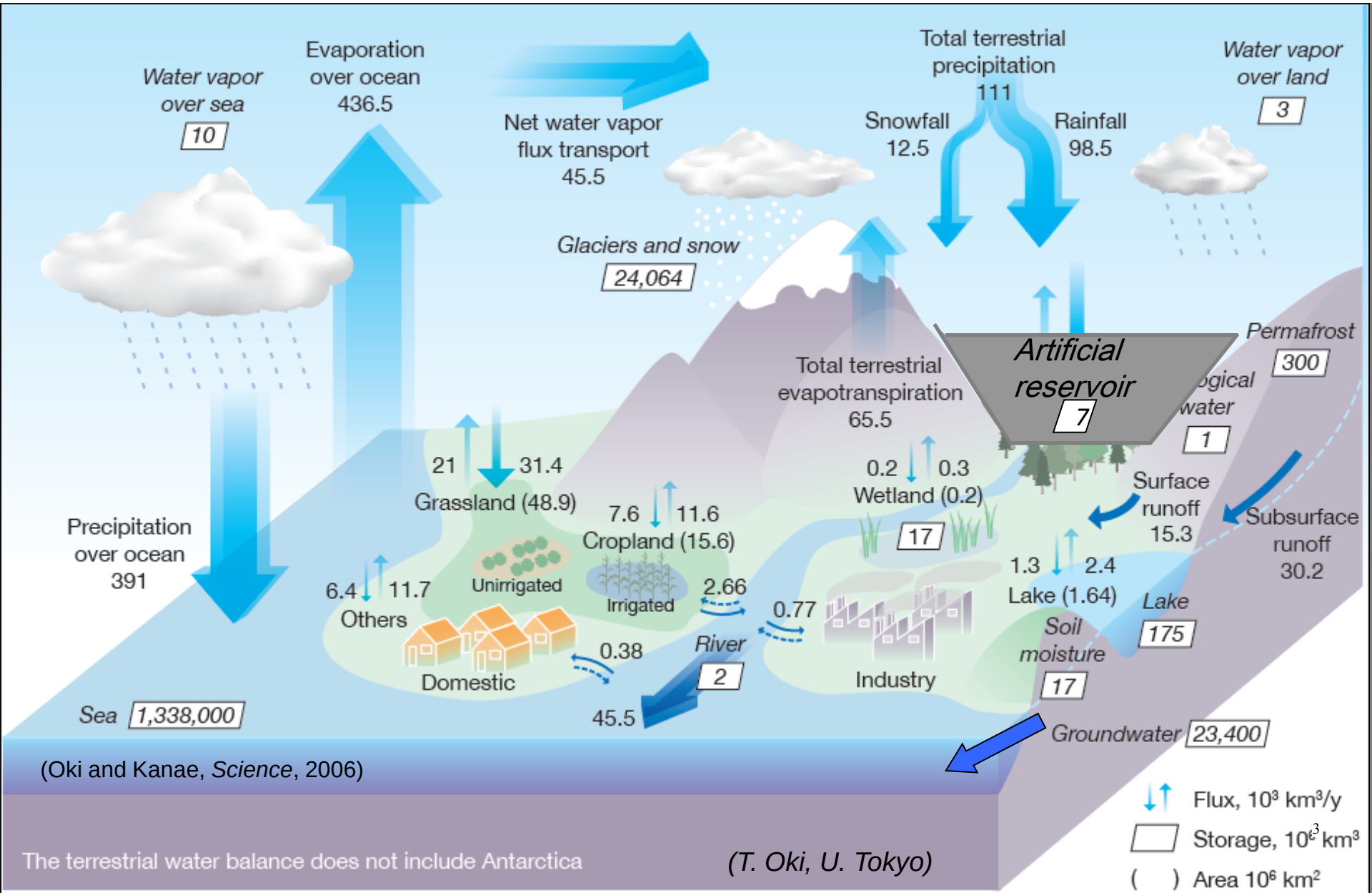
- **Precipitation observations?**
- **Model performance?**
- **Land-water processes models and observations?**



- **Hydrological sensitivity?**
- **Spatial pattern of precip change? ('wet wetter, dry drier'?)**
- **Regional changes to precipitation intensity (Convection?)**
- **Interactions between land water dynamics and atmospheric processes?**

- **Models improvements**
- **Modeling human impacts**

Physical system cannot be considered in isolation of human activities!



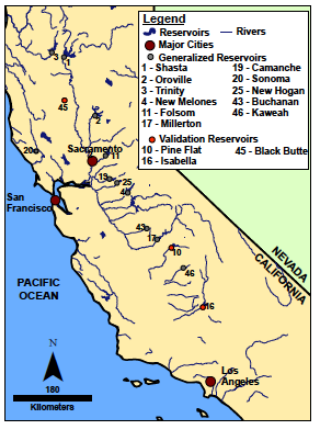
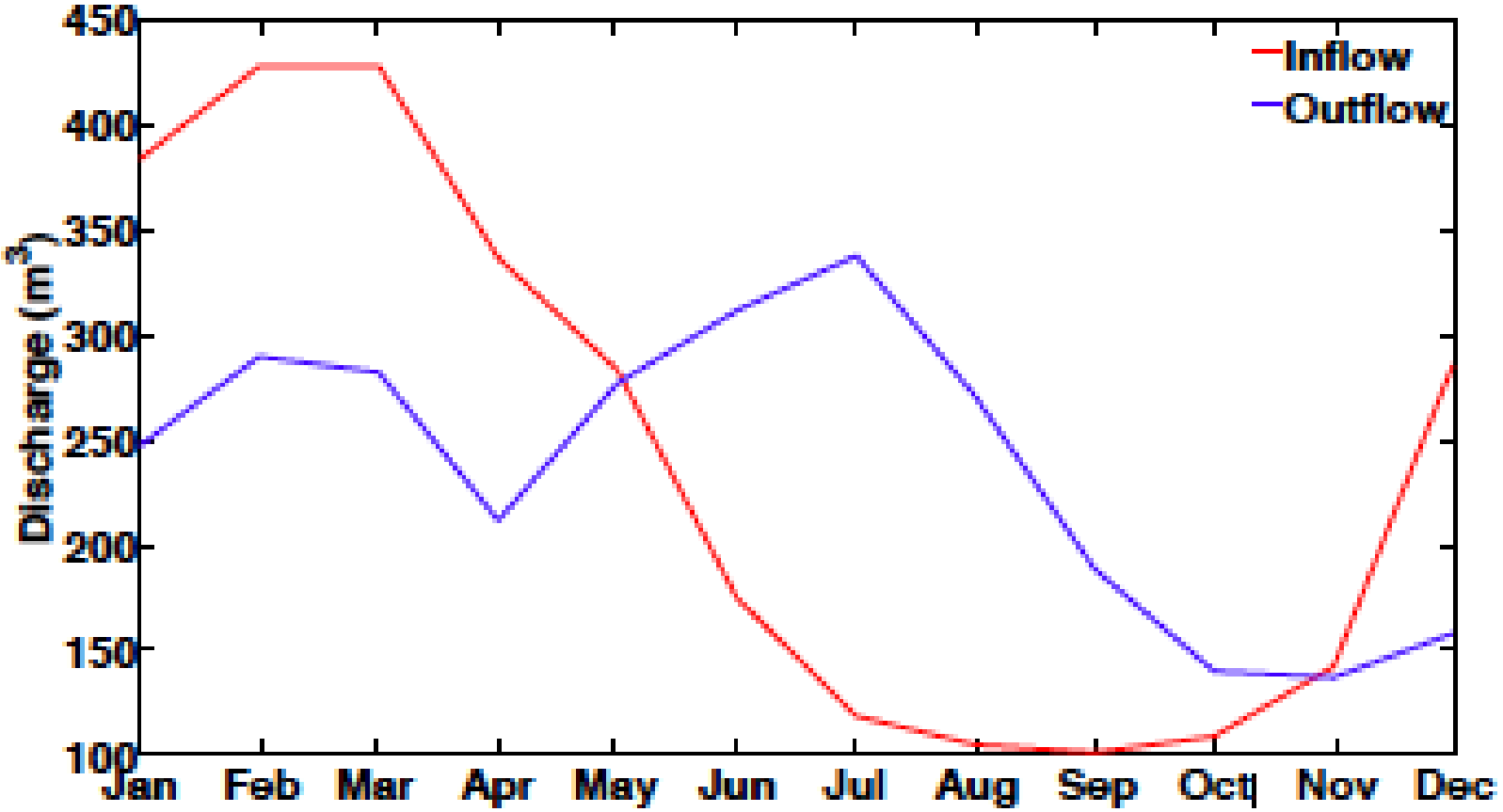


Figure 1: Locations of reservoirs used in model development. Numbers denote respective statewide storage capacity rank.

Putting the human impact into model systems is a glaring need - this need becomes more acute as model resolution increases

Solander et al., 2015



GEWEX PROES - Process Evaluation Studies underdevelopment

This grew out of the obs4mip meeting where participants felt the issue of using obs more intelligently to probe process understanding was needed

PROES is begiining to grow into a WCRP cross cut activity

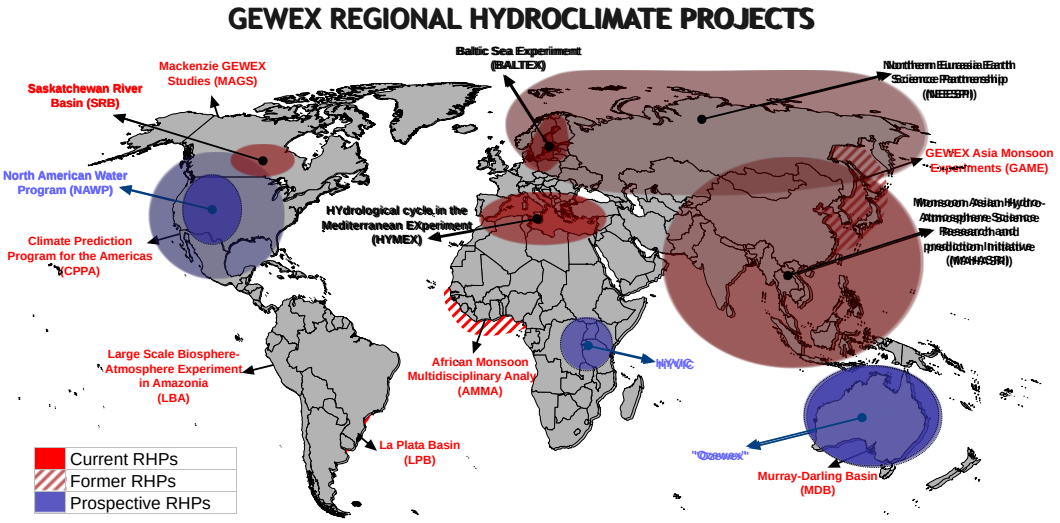
Five GEWEX-related PROES activities developing, one led by CliC

- Upper Tropospheric Clouds & Convection (UTCC, GEWEX and SPARC) lead Stubenrauch and Stephens
- Ice mass balance (lead Larour, Sophie Nowicki), GEWEX with CLiC
- Radiative Kernels for Climate (lead Soden)
- Mid-lat storms (lead Tselioudis, Jakob)
- Soil moisture climate (lead Sonia Seneviratne)

Might we develop a PRIMAVERA-centric PROES?
What would the focus be?

GEWEX Hydroclimatology Panel

- **Regional hydroclimate projects**
- Globally distributed extensive **regional data sets** : water and energy cycle observations (in situ and space borne and modeling data)
- **Global Data Centers**; data management system / GEO Prototype for Water Cycle Observations
- **Regional climate and hydrological modeling a**
- **Hydrological Applications** and Forecasting (Dr Ensemble Predictions…)
- http://www.gewex.org/projects-ghp.html



Under development is a US RHP – its scope is being defined now. It will be composed of multiple 'projects' - one dealing with water and the SW. This will be a combination of model and collecting relevant observations. NCAR has produced a 2003-2013 CONUS wide hydro-met simulation including the SasRB-CCRN @ 4km scale.

LPB BALTIC-EARTH
MAHASRI ✔OZEWEX
MDB
AMMA New
NEESPI ✔SasRB - CCRN