

# ***GEWEX/GLASS Panel Project Updates and relevance to WGNE***

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**GLASS panel members and other GEWEX collaborators**

**Global Energy and Water Cycle Exchanges Project (GEWEX)  
Global Land/Atmosphere System Study (GLASS)**

**34th session of the Working Group on Numerical  
Experimentation (WGNE-34)**



**WGNE-34, DWD, Offenbach  
24-27 September 2019**



# ***GLASS Vision and Mission***

## **The GEWEX Vision:**

Water and energy are fundamental for life on Earth. Fresh water is a major pressure point for society owing to increasing demand and vagaries of climate. Extremes of droughts, heat waves and wildfires, as well as floods, heavy rains, and intense storms increasingly threaten to cause havoc as the climate changes. Other challenges exist on how clouds and aerosols affect energy and climate. Better observations and analysis of these phenomena, and improving our ability to model and predict them, will contribute to increasing information needed by society and decision makers for future planning.

***GLASS role: Better representation of the Earth System by understanding the role of land.***

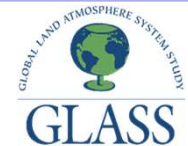
## **The GEWEX Mission:**

To measure and predict global and regional energy and water variations, trends, and extremes, such as heat waves, floods, and droughts, through improved observations and modeling of land, atmosphere, and their interaction, thereby providing the scientific underpinnings of climate services.

***GLASS role: Identify and improve modeling of land-surface processes and land-atmosphere interactions to support the GEWEX Mission.***

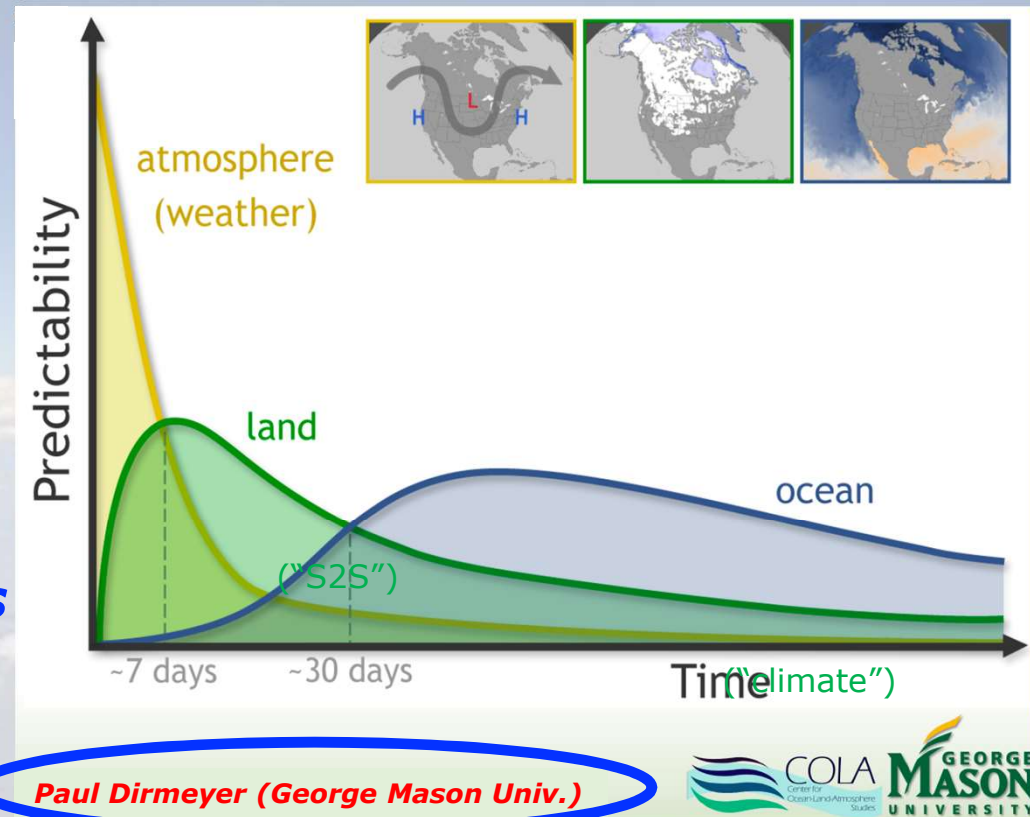


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# Why Land Processes and Land-Atmosphere Interaction? Predictability and Prediction!

- Land states, i.e. **soil moisture, snow** and **soil temperature**, can provide predictability in the window from deterministic **weather ("day-zero") to climate (Ocean-Atmosphere)**.
- Vegetation** states, related to soil moisture anomalies, give predictability at and beyond S2S time scales.
- L-A coupling active where there is **sensitivity, variability** and **memory**.
- Good models & analyses** (of atmosphere and land states) needed to exploit this source of skill.





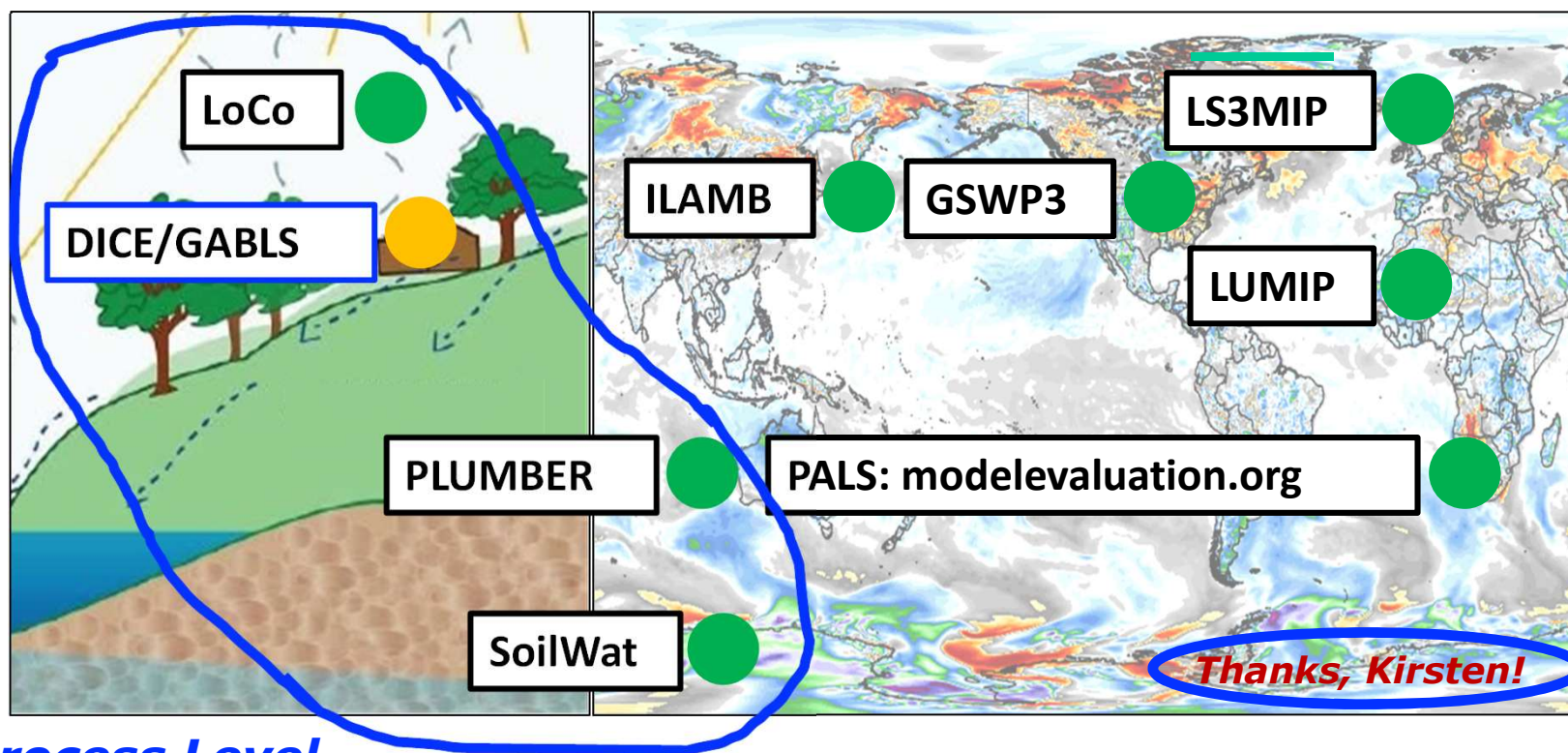
# GLASS Structure

**GLASS role: Identify and improve modeling of land-surface processes and land-atmosphere interactions to support the GEWEX Mission.**

Process-oriented

Benchmarking

Model Intercomparisons



**Process Level**

# ***PLUMBER: Aims + results***

## **PLUMBER**

### ***PALS Land sUrface Model Benchmarking Evaluation pRoject***

(PALS: Protocol for the Analysis of Land Surface models)

***Gauge whether land models (LSs) are performing as well as they could, given the information they're provided with, and if not, identify practical avenues for model improvement.***

- ***First phase of PLUMBER was site-based MIP*** using out-of-sample empirical models as benchmarks to define performance expectations.
- ***LMs consistently outperformed by linear regressions*** against downward shortwave when predicting sensible heat flux.
- ***Finding: Out-of-sample empirical models could outperform LMs:*** LMs can perform much better than they currently do, given the amount of information they are provided with in meteorological forcing data.
- ***Participants:*** **Gab Abramowitz**, Martin de Kauwe, Anna Ukkola, Martin Best, Martyn Clark, Sujay Kumar, Dave Lawrence, Grey Nearing, others.

***PALS: Modevaluation.org*** (previously "Protocol for the Analysis of Land Surface models") ***Web-based testbed & workflow environment aids standardizing LM evaluation; a priori benchmarking focus.***

## ***PLUMBER: Future***

- ***PLUMBER2 launch soon***: Flux tower data processing nearly complete (200-300 sites).
- ***PLUMBER2 protocol***: feedback from 10+ panel members, essentially ready.
- ***Increased focus on process representation***: more model variables, input-state-flux pathway analysis, variable ratio analysis, budget analysis.
- ***Improved empirical models*** and information-theory based analyses.
- ***Synthetic forcing experiments*** to diagnose model behaviour.
- ***Land data assimilation***: in discussion with Sujay Kumar for land DA in PLUMBER2, active discussion among several land DA leaders: Clara Draper (NOAA), Clément Albergel (M-F), Patricia De Rosnay (ECMWF).
- ***Urban-PLUMBER***: in discussion with Mat Lipson, Sue Grimmond, Martin Best for urban-PLUMBER in 2020.
- ***Hydrological component*** to be included in a future phase of PLUMBER (Martyn Clark).

# SoilWat Project

## SoilWat      GEWEX Soils and Water initiative

**Goal:** To improve the representation of soil and subsurface processes in climate models and to identify the most pressing challenges and topics related to this effort.

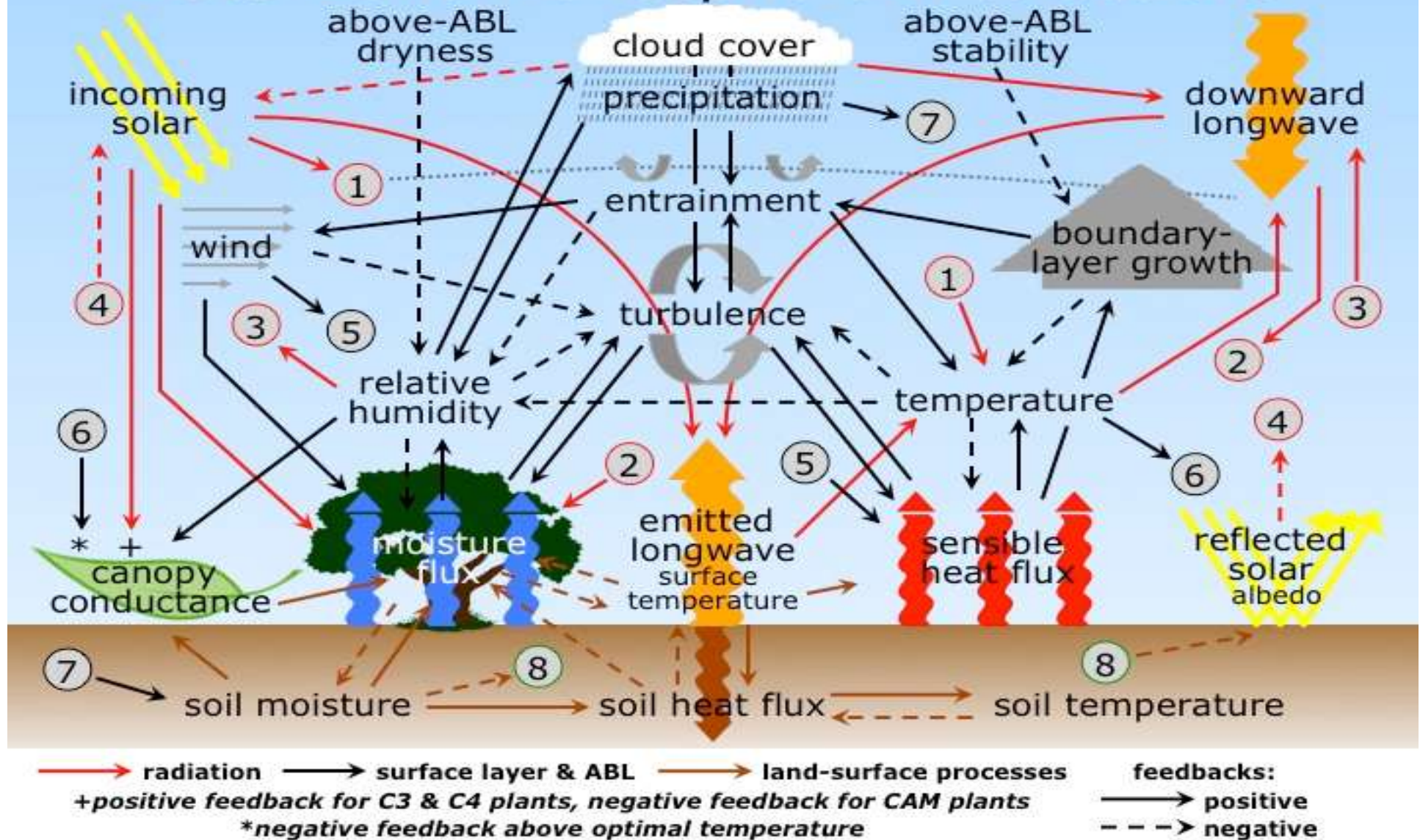
**Participants:** Dani Or, Matthias Cuntz, **Anne Verhoef**, Harry Vereecken, Lutz Weihermuller, Lukas Gudmundsson, Peter Lehmann, Stefan Kollet, Simone Fatichi, Mehdi Rahmati plus many others.

**Activities:** review paper on *"Infiltration for land modelling"*; Surveying *hydraulic/thermal pedotransfer functions* used in land models; Discussion paper on *groundwater* in global hydrological/climate models; conducting a *global soil parameter MIP*; Assessing the effects of *soil structure on land surface fluxes*; Using SoilGrids to revise *global surface evaporation*.

**Outline of future work:** Determination of *global thermal properties* from soil texture & mineralogy data; *new generation PTFs* to inject soil structure into soil hydraulic properties. Future PLUMBER phase.



# Local Land-Atmosphere Interactions





## Diurnal land/atmosphere coupling experiment (DICE)

- **Joint GLASS (land) - GASS (PBL/atmosphere) project; follow on to GEWEX Atmospheric Boundary Layer Study (GABLS) #2, where land-atmosphere coupling was identified as a important mechanism.**



**Objectives:** Assess impact of land-atmosphere feedbacks.

Stage 1: stand alone land, and single column model (SCM) alone.

Stage 2: Coupled land-SCM.

Stage 3: Sensitivity of LMs & SCMs to variations in forcing.

**Findings so far:** Differences in models' (LM+SCM) sensitivity to changes in forcing likely important in ESMs; needs better understanding. Examine further: surface momentum flux & profiles; large errors in evaporation dominate signal and impact of coupling; nocturnal fluxes/boundary layers, soil-surface coupling.

- **GABLS4/DICE-over-ice: Antarctica, snow/ice, strongly stable conditions.**

- **Additional sites over a broad geographical range, e.g. LIASE (semi-arid).**

# Local (land-atmosphere) Coupling (LoCo) Working Group

## LoCo WG Objective:

**Joe Santanello (NASA Goddard) et al.**

***To understand, model, and predict the role of local land-atmosphere coupling in the evolution of land-atmosphere fluxes and state variables, and the respective water and energy cycles, including clouds.***

## Goals (last 1-2 years):

- Promote **improved observations** of the L-A system, namely PBL profiles, improved use of soil moisture and surface fluxes measurements in models.
- Pursue **adoption of LoCo metrics** by operational NWP and Climate Centers.
- **Expand scope and reach of LoCo** beyond warm season & 1-D assumptions.
- **PBL observations cited as most important measurement in the 2017** NASA Decadal Survey (DS). LoCo WG white papers to DS on importance of PBL measurements -> funding opportunities for PBL instruments and modeling.
- **US Climate Modeling Summit** (04.2018) -> NOAA Climate Process Team (CPT) & NASA Water Cycle Study (NEWS) solicitations. Multi-institute land CPT.

## Near-term Plans:

- **Continue to coordinate field campaign and LoCo-based analysis activities** from recent & planned campaigns such as LAFE, GRAINEX, LIAISE.
- **Engage operational centers** via NOAA CPTs, NASA NEWS, NCAR Joint Numerical Testbed and Developmental Testbed Center activities/collaborations.
- **Influence PBL mission development** via NASA DS opportunities (ROSES).
- **Coordinated expansion of LoCo scope** via proposals and experiments.



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# LAND-ATMOSPHERE INTERACTIONS

The LoCo Perspective

4<sup>th</sup>  
most-read  
on BAMS  
website

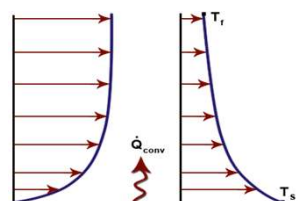
JOSEPH A. SANTANELLO JR., PAUL A. DIRMAYER, CRAIG R. FERGUSON,  
KIRSTEN L. FINDELL, AHMED B. TAWFIK, ALEXIS BERG, MICHAEL EK, PIERRE GENTINE,  
BENOIT P. GUILLOD, CHIEL VAN HEERWAARDEN, JOSHUA ROUNDY, AND VOLKER WULFMEYER

Metrics derived by the LoCo working group have matured and begun to enter the mainstream, signaling the success of the GEWEX approach to foster grassroots participation



# Hierarchical System (or Model) Development ("HSD")

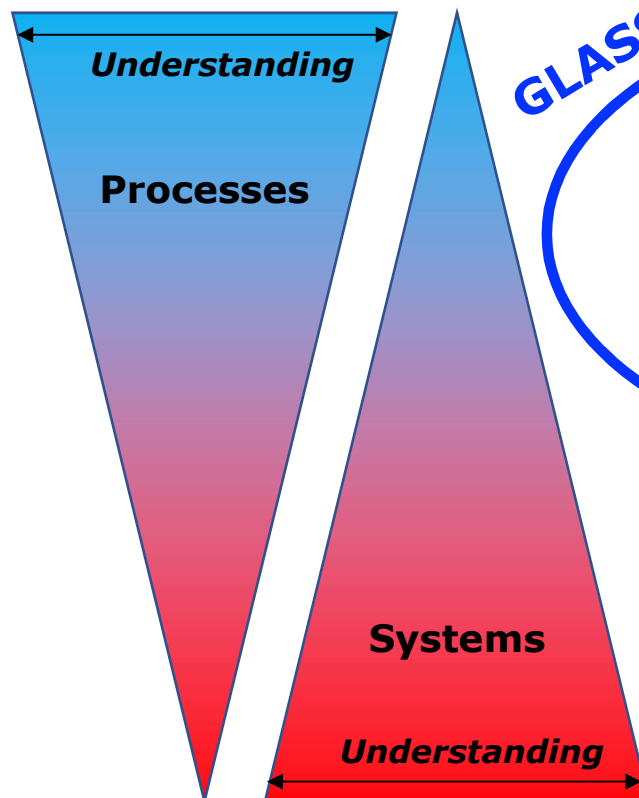
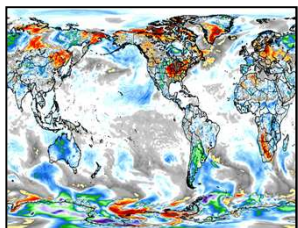
## A simple-to-more-complex systematic approach



"Simple"  
Processes



Complex  
Systems



GLASS

### HSD Testing "Harness"

Parameterization Simulator

Single Column Model

2-D Model

Limited-Area Domain

Regional Model

Global Model

Fully-Coupled Model

### Recent assessment of the World Climate Research Programme:

- Improved understanding of earth system at the process level. Better connect Weather (WWRP) & Climate (WCRP): NWP-S2S-Climate –J. Slingo, UKMO.
- "Need a back to basics approach" –G. Stephens, JPL.
- "More model developers!" –C. Jakob, Monash Univ., Aust.



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# ***International Subseasonal-to-Seasonal Prediction Project***

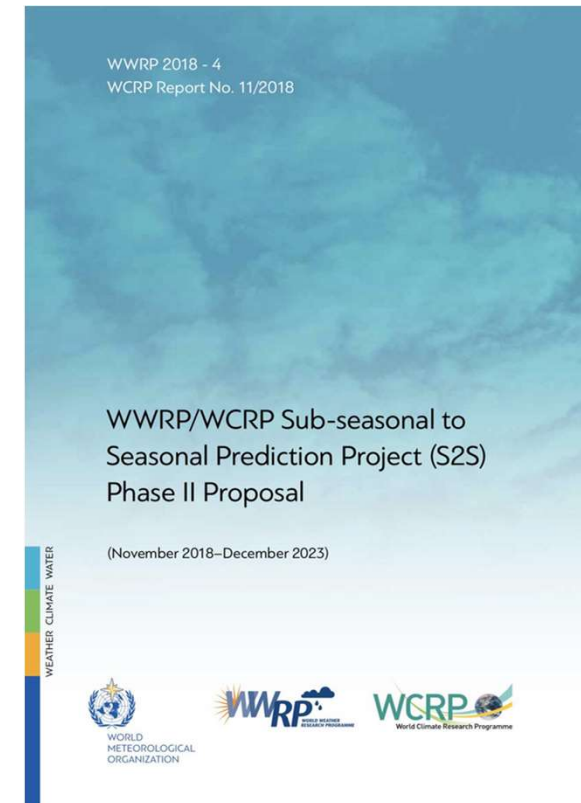
**Proposal for a 5-year “Phase II” was approved by WMO.**

*Expanded research activities include new focus on land initialization & L-A feedback:*

- 1. What is the impact of the **observing system** on **land initialization** and **S2S forecasts**?*
- 2. How well are the **coupled land/atmosphere processes** represented in **S2S models**?*
- 3. How might **anomalies in land states** contribute to extremes?*

*Clear relevance to GLASS, GASS, GDAP.*

Otherwise, **more emphasis on data consistency between models, completeness, user applications.**



***Paul Dirmeyer (George Mason Univ.) – liaison from GLASS***