

GSFC's Land Data Assimilation Systems:

An Ensemble Land Surface Modeling and Assimilation Testbed for HEPEX

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Hydrological Sciences Branch
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Acknowledgements:

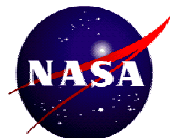
Many collaborators (NOAA/NCEP, NOAA/OHD, Princeton, Rutgers, UW, COLA, ...)

Support from:

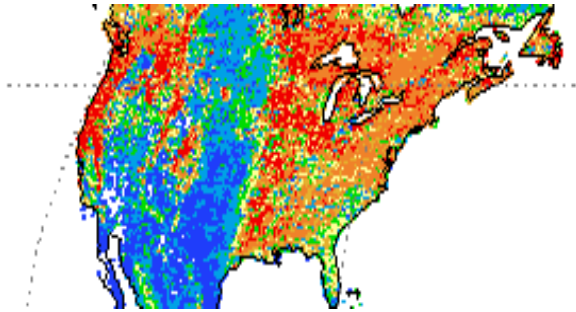
*GCIP/GAPP,
NASA Terrestrial Hydrology Program
NASA ESTO/Computational Technologies Program*

<http://ldas.gsfc.nasa.gov>

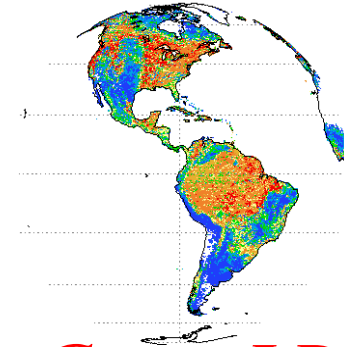
<http://lis.gsfc.nasa.gov>



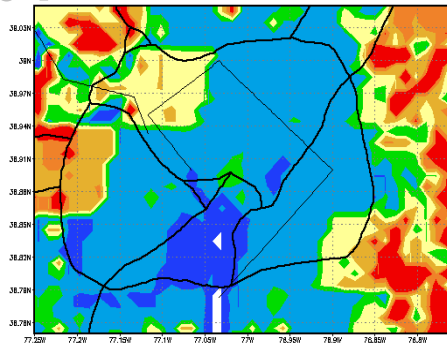
GSFC's Land Data Assimilation Systems



North American *LDAS*
1/8 Degree Resolution
Mitchell et al., JGR, 2004

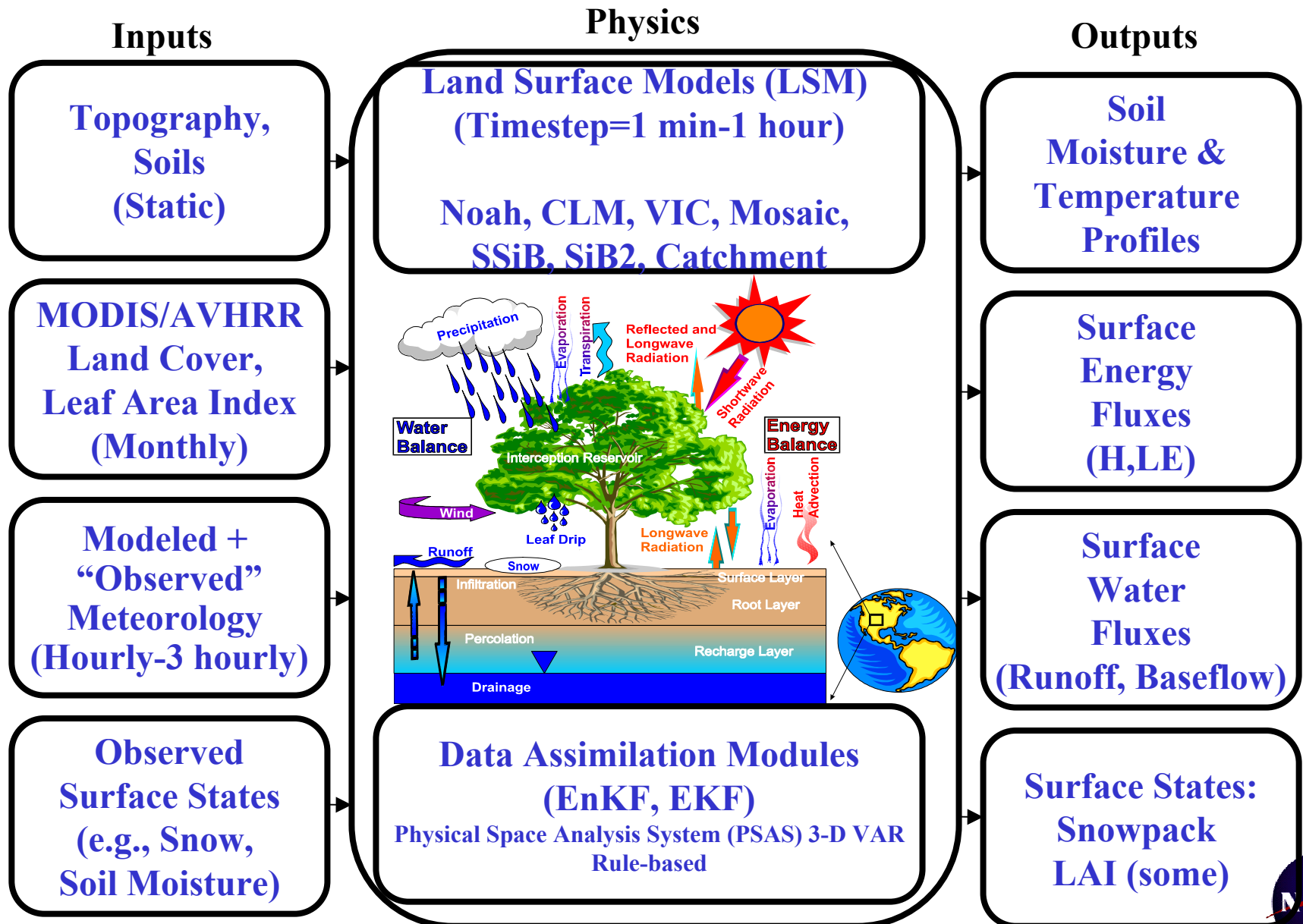


Global *LDAS*
1/4 Degree Resolution
Rodell et al., BAMS, 2004



Land *Information System*
Variable (2 deg-1km) Resolution
Peters-Lidard et al., AMS, 2004

LDAS/LIS Modeling Approach



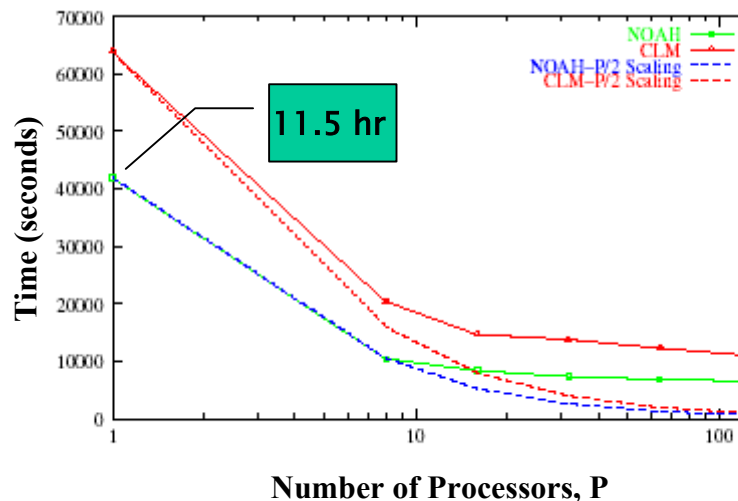
LIS High Performance Computing

Simulation: one day, 15 minute time step

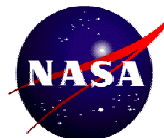
a. Performance improvement at $\frac{1}{4}^\circ$ resolution

	Memory (MB)	Wallclock time (minutes)	CPU time (minutes)
LDAS	3169	116.7	115.8
LIS	313	22	21.8
reduction factor	10.12	5.3	5.3

b. Scaling curves at 5km resolution

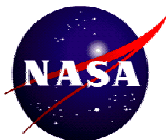


- solid lines depict LIS results on SGI O3K at NASA/ARC
- hatched lines depict LIS goal of P/2 scaling



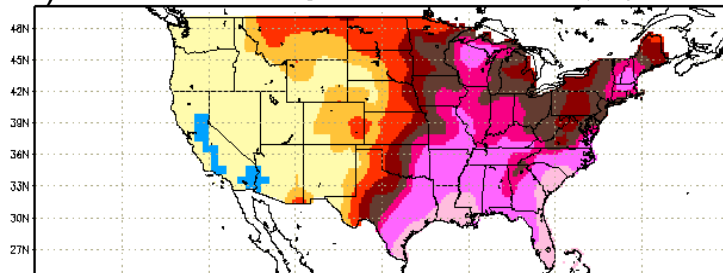
Ensembles in LIS

- Physics
 - Noah, CLM, VIC, Mosaic, etc.
 - (could perturb initial conditions)
- Forcing
 - Models: NOAA/GDAS, NASA/GEOS, ECMWF
 - Precipitation: NRL/Turk, GSFC/Huffman, Persiann, CMAP, CMORPH
 - Radiation: GOES SRB (US), AGRMET-based
 - (could be analysis/forecast members)
- Parameters
 - Land Cover: AVHRR climatology or MODIS real-time
 - Subgrid “tiles” or nested fine grid at 1km
 - (could use PDF’s of soil/land cover parameters)



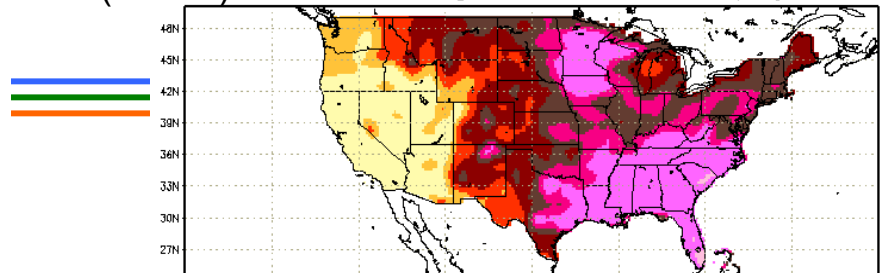
(GEOS)

Jun 2002 - Aug 2002 GEOS Total Pcp (MM)



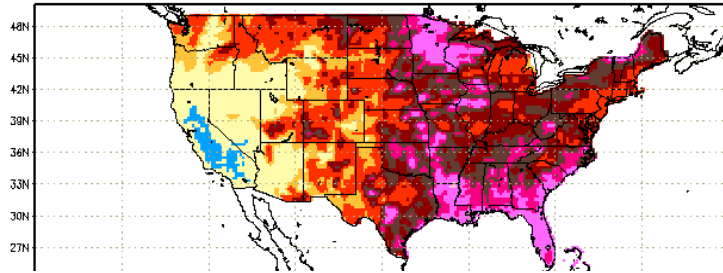
(GDAS)

Jun 2002 - Aug 2002 GDAS Total Pcp (MM)



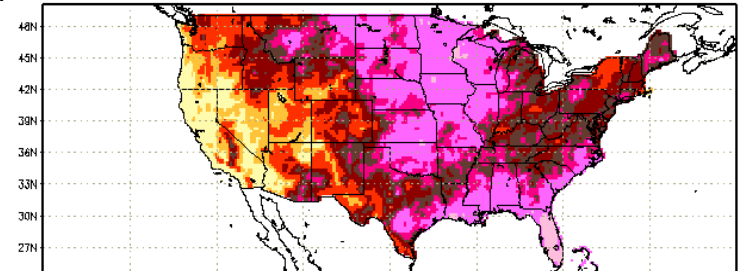
(ECMV)

Jun 2002 - Aug 2002 ECMWF Total Pcp (MM)



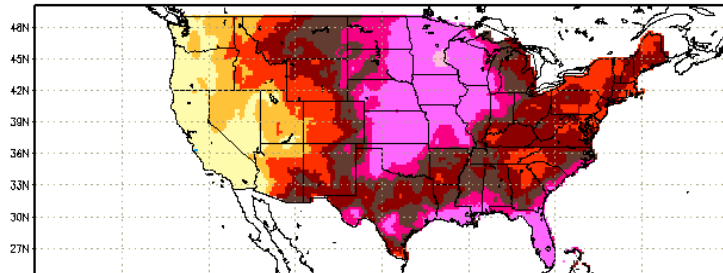
(Hurr)

Jun 2002 - Aug 2002 Huffman Total Pcp (MM)



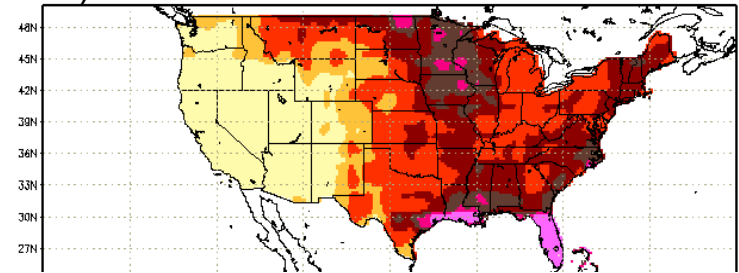
(Persiann)

Jun 2002 - Aug 2002 Persiann Total Pcp (MM)



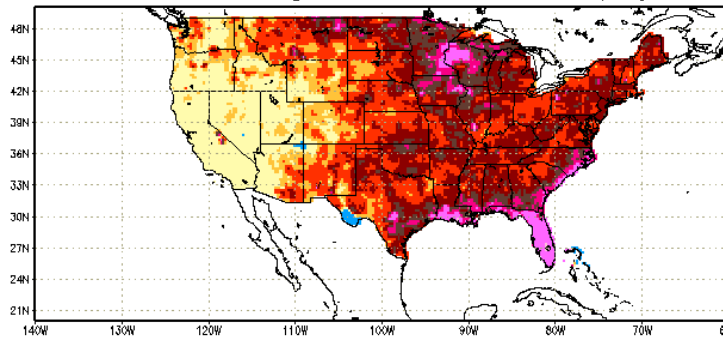
(CMAP)

Jun 2002 - Aug 2002 CMAP Total Pcp (MM)



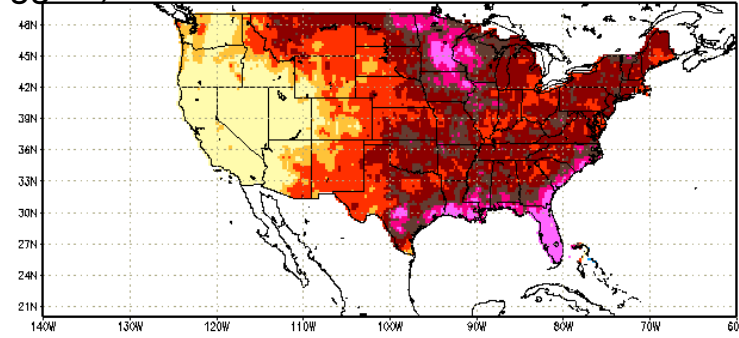
(NEXF)

Jun 2002 - Aug 2002 NEXRAD Total Pcp (MM)

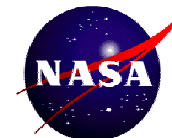
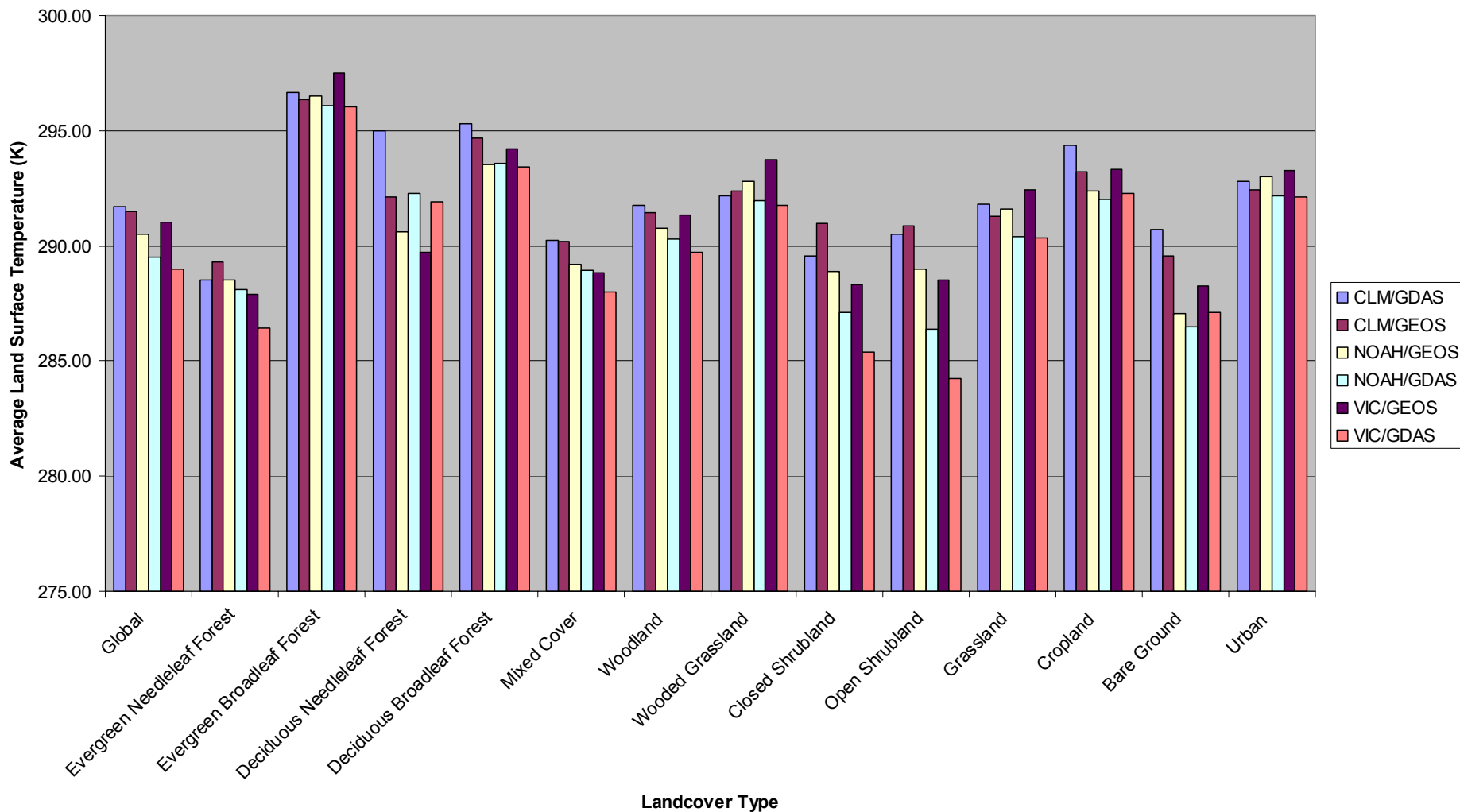


(Higgins)

Jun 2002 - Aug 2002 Higgins Total Pcp (MM)

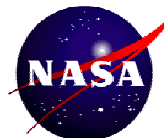
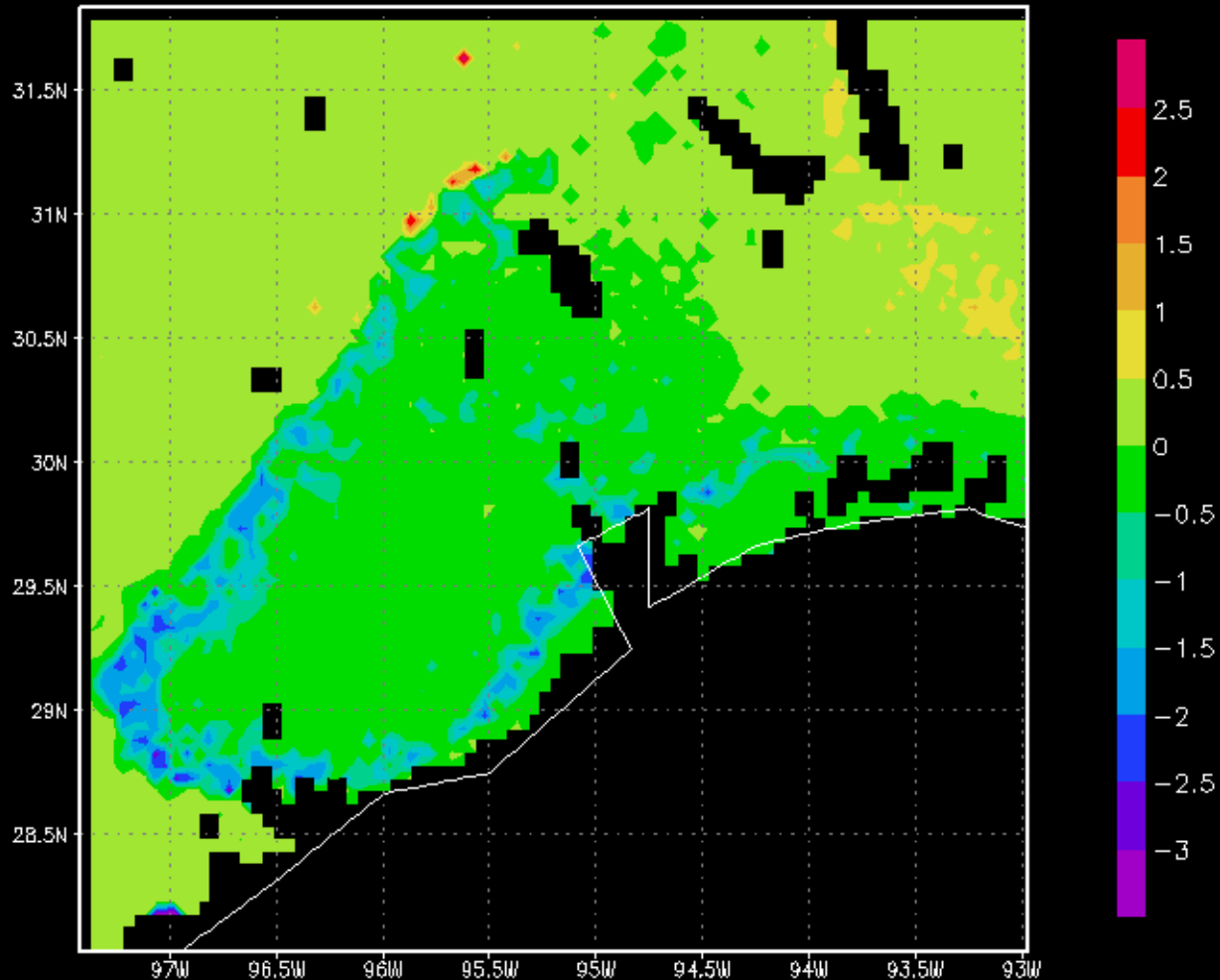


Example: LIS Physics/Forcing Ensemble



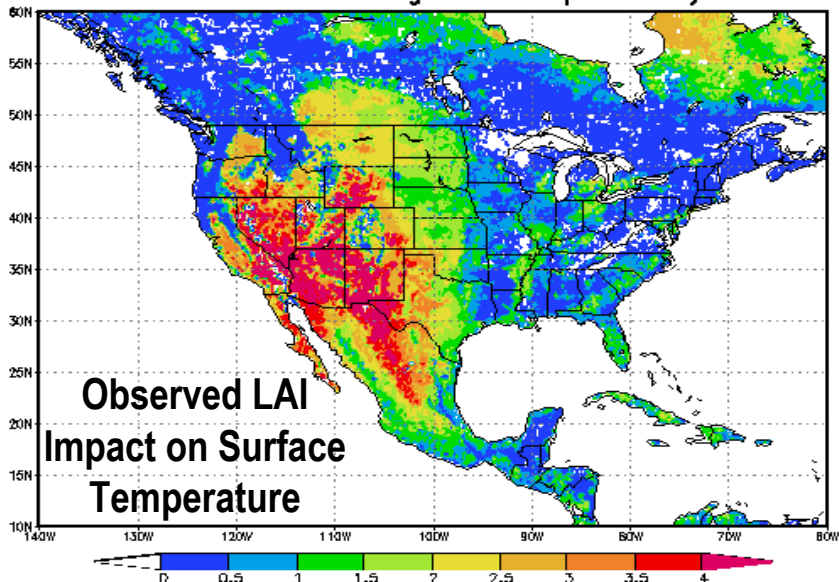
Impact of Observed vs. Modeled Forcing

August 22, 2002 22UTC Surface Temperature Differences
(GDAS+CMAP+AGRMET – GDAS)

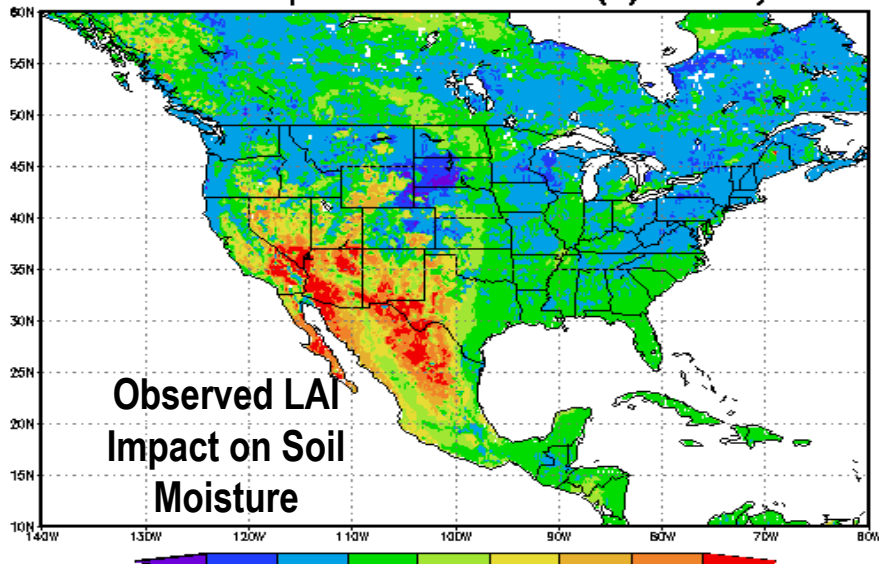


Impact of Observed LAI

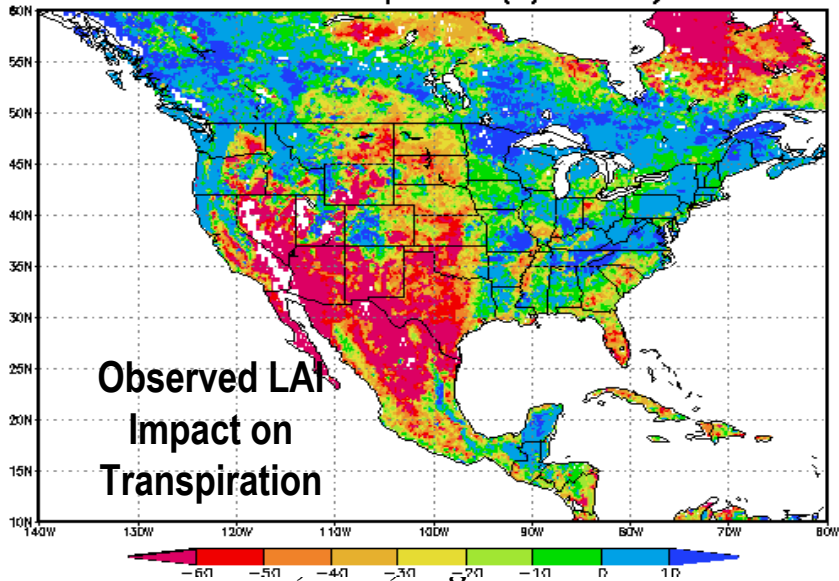
AVHRR-INDEX -- Average Sfc Temp -- July 2001



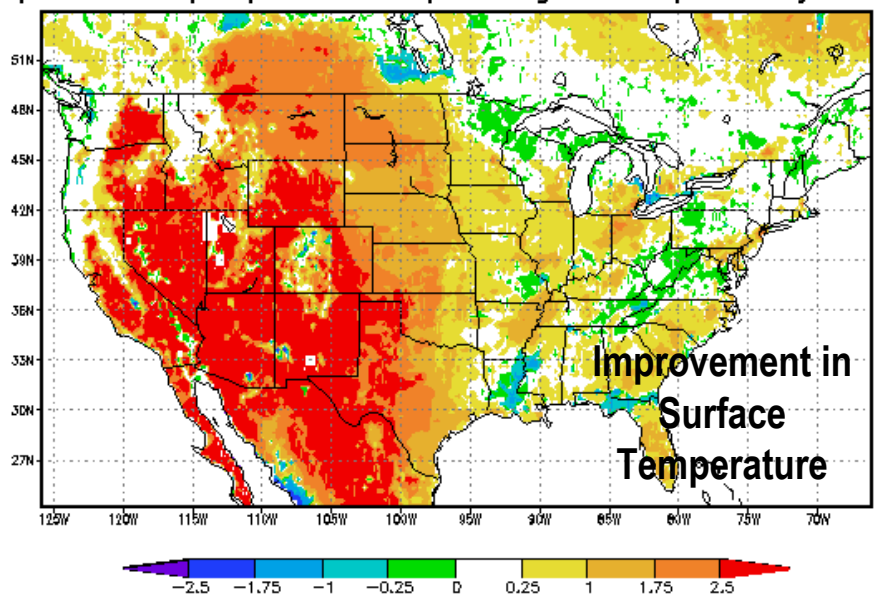
AVHRR-INDEX Top 1 m Soil Moisture (%) -- July 2001



AVHRR-INDEX Transpiration (%) -- July 2001

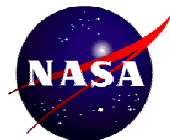


|GOES-INDEX| - |GOES-AVHRR| -- Avg Sfc Temp -- July 2001

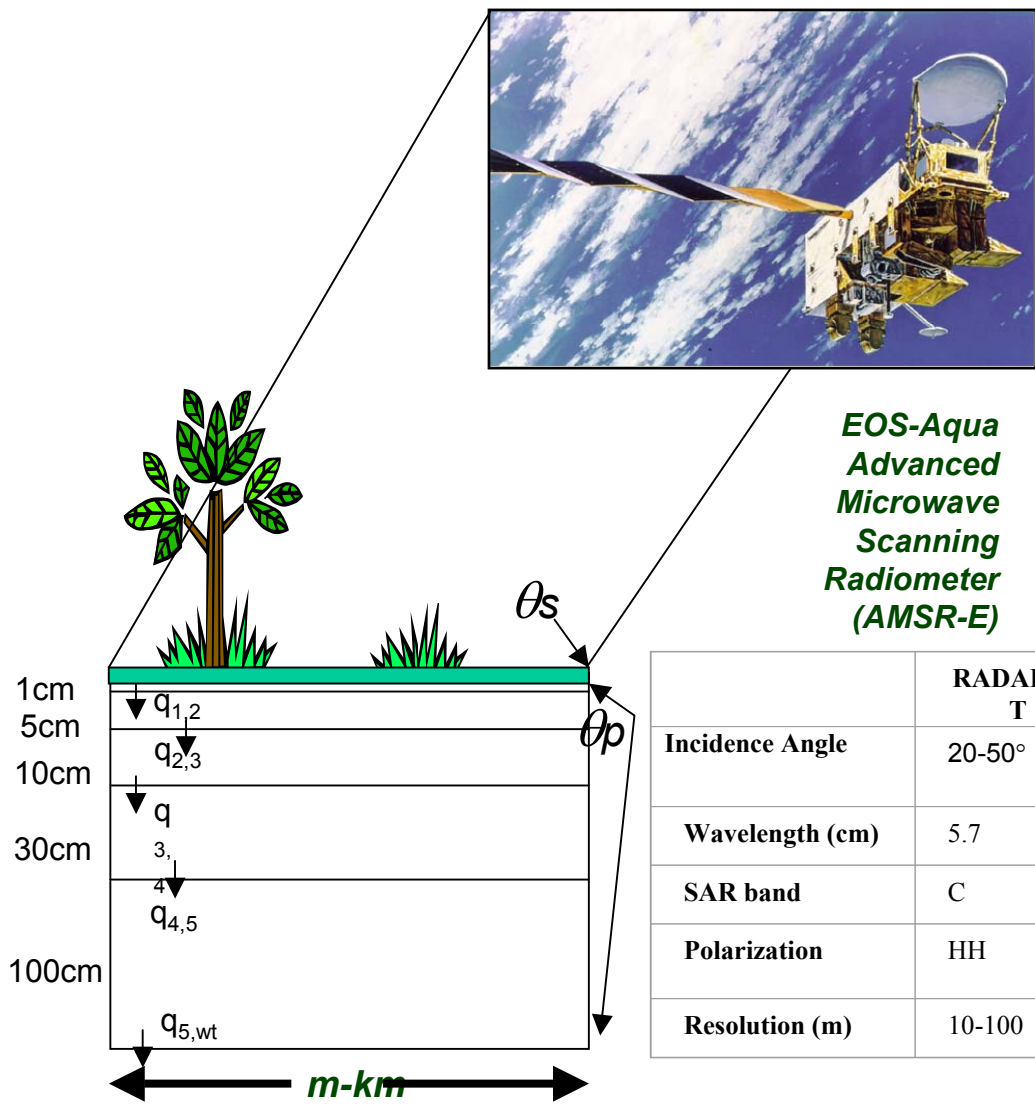


LDAS/LIS Data Assimilation

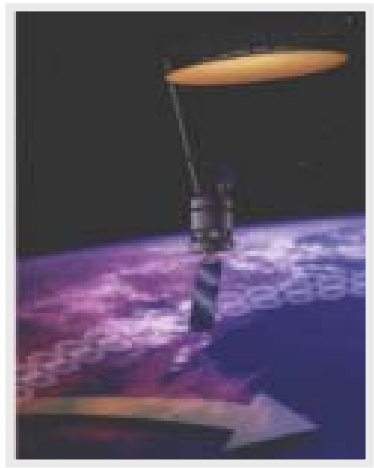
- Soil Moisture
- Skin Temperature
- Snow Cover and SWE
- Total Water Storage



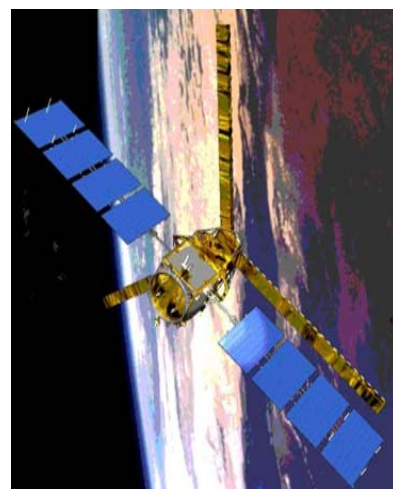
Assimilation: Soil Moisture



*EOS-Aqua
Advanced
Microwave
Scanning
Radiometer
(AMSR-E)*



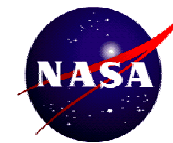
*HYDROSpheric States
Mission*



*ESA Soil Moisture and
Ocean Salinity (SMOS)
Mission*

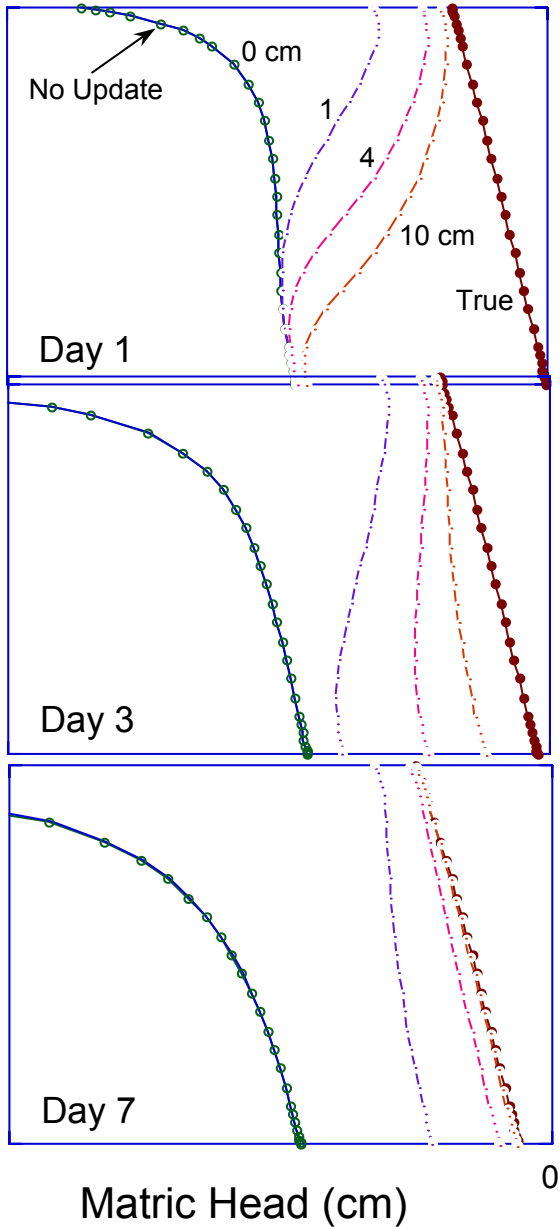
	RADARSAT T	ERS SAR	ERS ENVISAT ASAR	JERS ALOS PALSAR (planned)
Incidence Angle	20-50°	23°	15-45°	10-51°
Wavelength (cm)	5.7	5.7	5.7	23
SAR band	C	C	C	L
Polarization	HH	VV	HH, VV, VH, HV	HH, VV, HH, HV, VV & VH
Resolution (m)	10-100	30	10-100	10-100

**SSMIS
NPOESS**



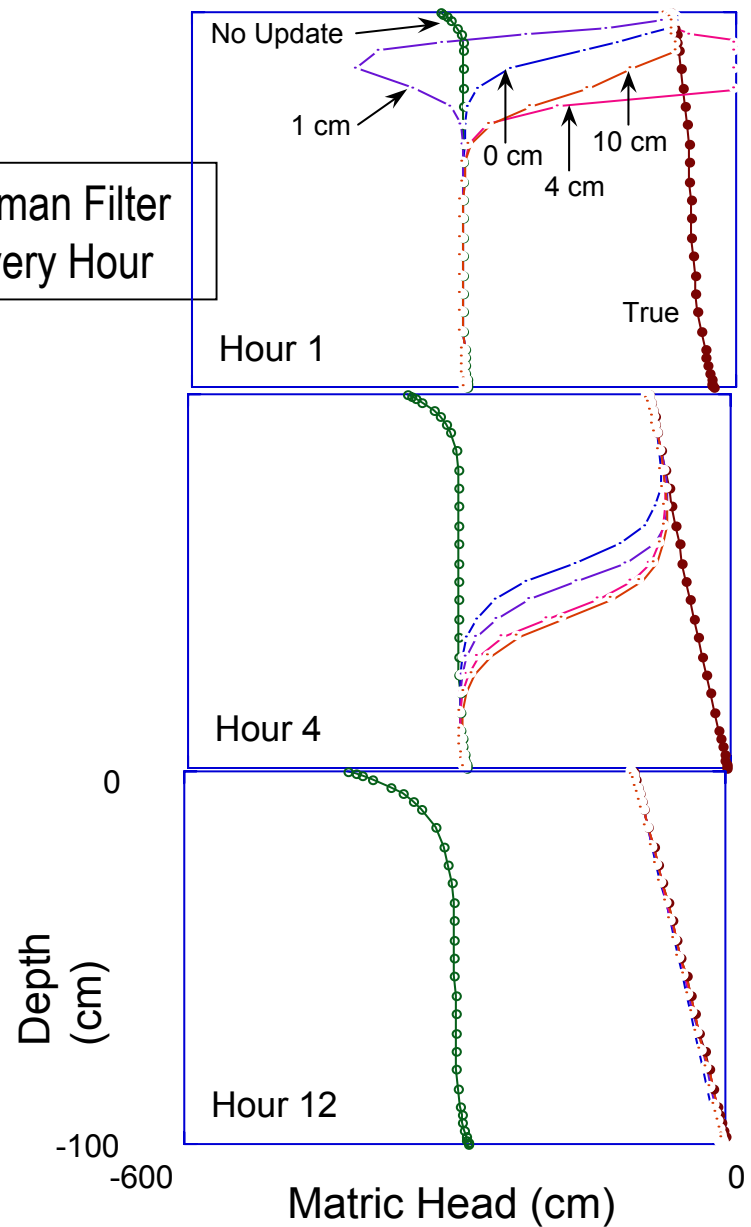
KF Soil Moisture Profile Estimation

Direct Insertion
Every Hour

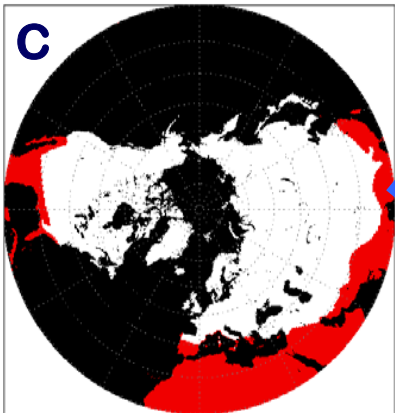
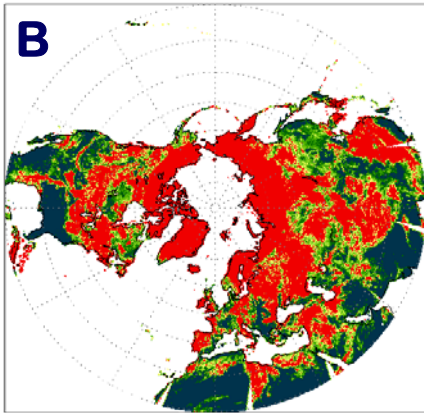
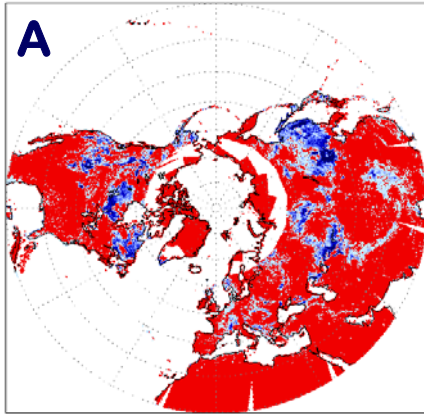


Source: Jeff
Walker

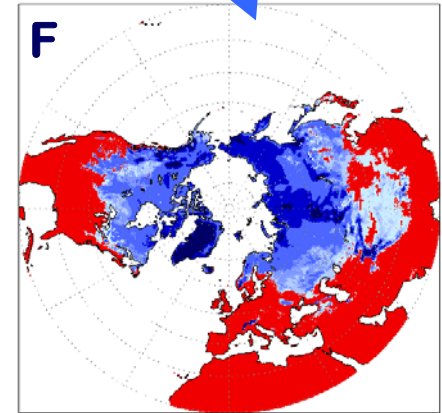
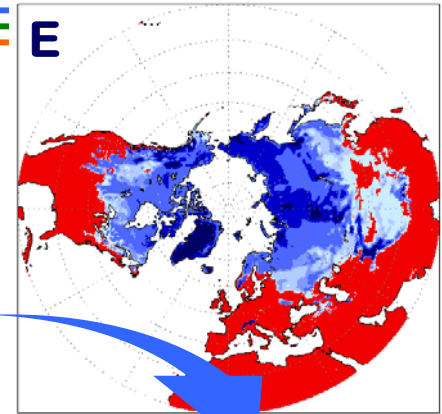
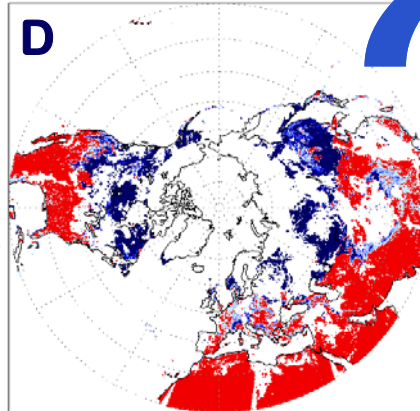
Kalman Filter
Every Hour



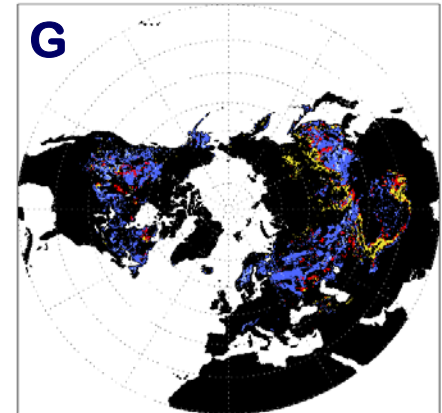
Assimilation: Snow



Original MODIS visible snow cover (%) **A** is modified using MODIS confidence index (total visibility; %) **B** and a snow impossible mask **C** in order to produce an enhanced snow field **D**.

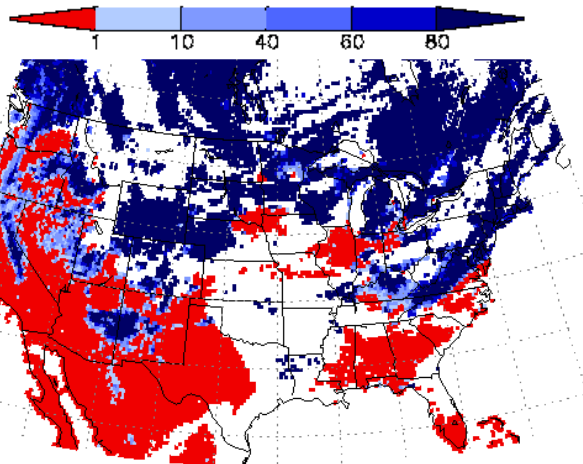


This is used to update the modeled snow on a daily basis. Output snow depth (mm H₂O) is shown for 30 November 2000, after running the Mosaic LSM without **E** and with **F** the snow correction for 30 days. Map **G** shows the difference (mm H₂O) between the two results.



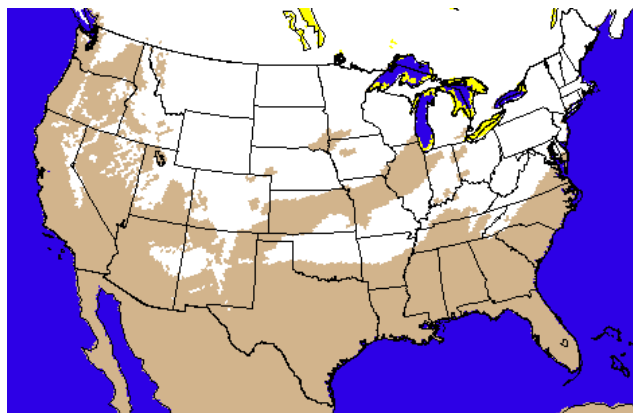
Assimilation: Snow

Enhanced MODIS
Snow Cover (%)

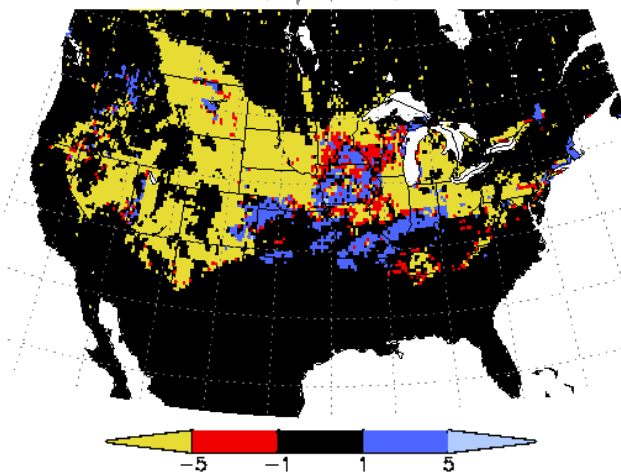
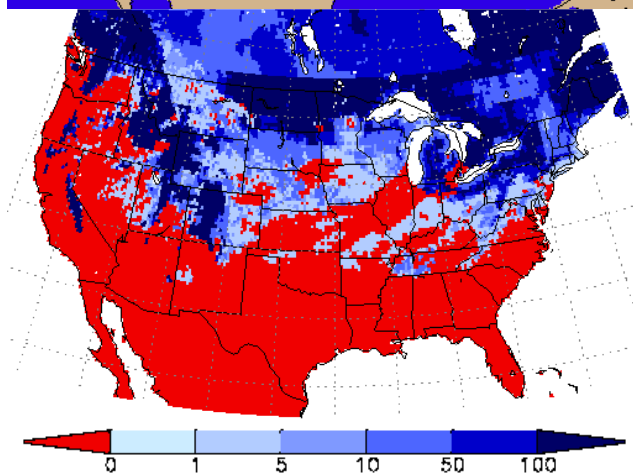
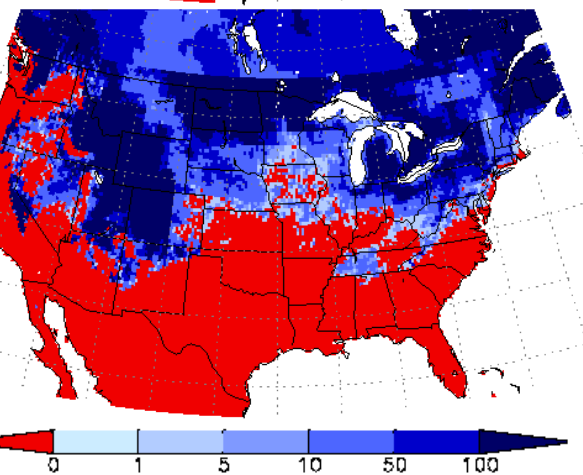
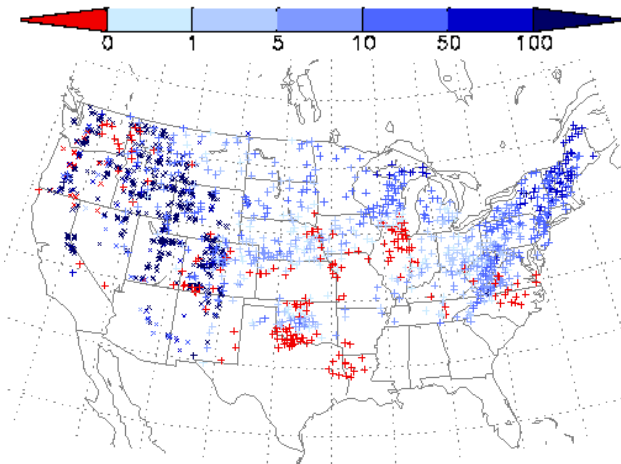


21Z 9 February 2003

IMS Snow Cover



SNOTEL and Co-op
Network SWE (mm)



Control Run Mosaic
SWE (mm)

Assimilated Mosaic
SWE (mm)

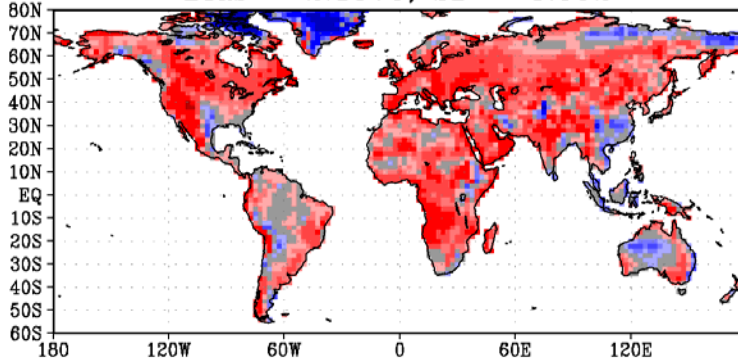
Mosaic SWE Difference
(mm)

Assimilation: Skin Temperature

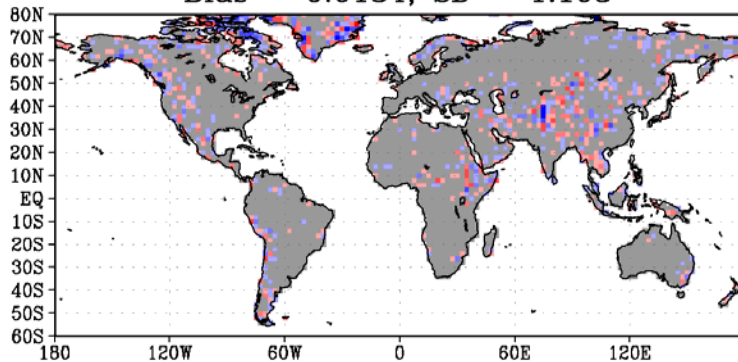
DAO-PSAS **Assimilation of ISCCP (IR based) Surface Skin Temperature** into a global 2 degree uncoupled land model.

JJA 1992 Skin Temperature (K)

Model - Obs
Bias = 2.1570; SD = 3.592



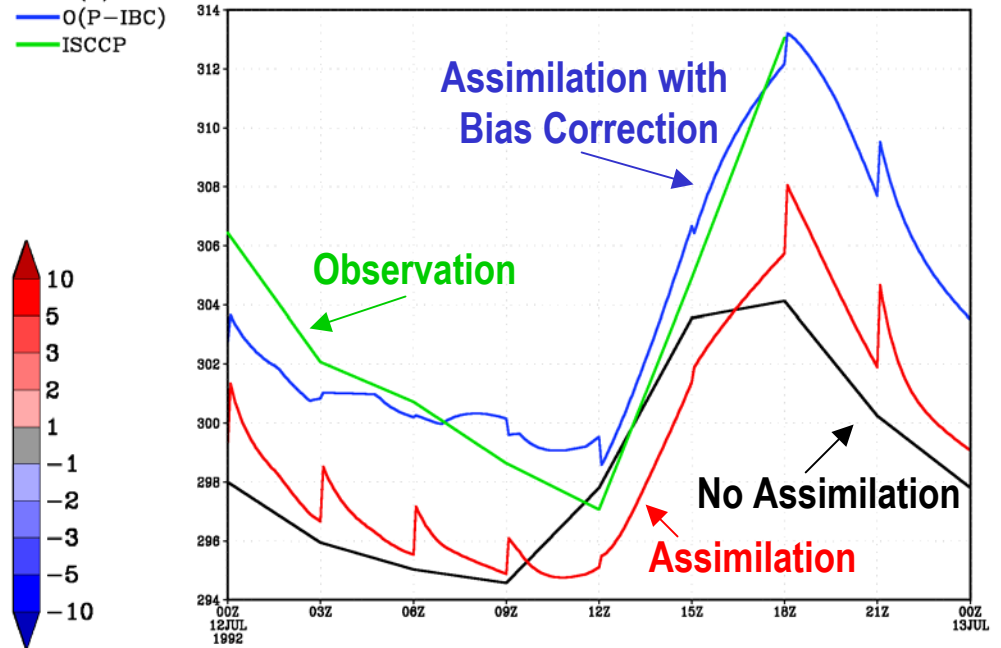
Assim.V - Obs
Bias = 0.0134; SD = 1.103



MARCH 0-10, 2004, Page 13

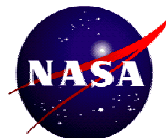
— OLGA
— O(P)
— O(P-IBC)
— ISCCP

Surface Skin Temperature (K) 34°,-100°

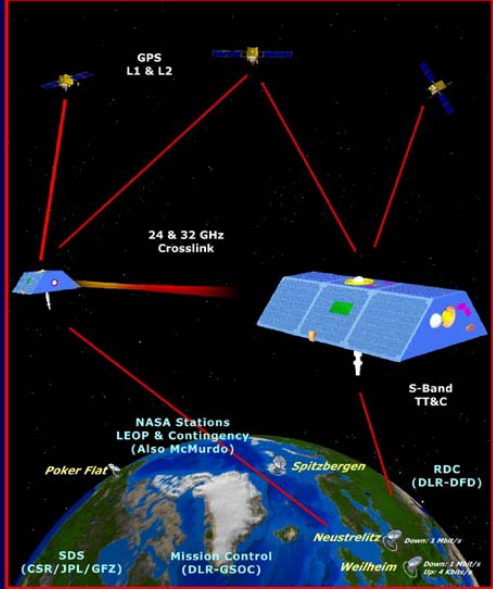


Surface temperature has very little memory or inertia, so without a continuous correction, it drifts toward the control case very quickly.

Christa D. Peters-Lidard, Ph.D.
GSFC Hydrological Sciences Branch



Assimilation: GRACE Water Storage



GRACE Mission

Science Goals
High resolution, mean & time variable gravity field mapping for Earth System Science applications.

Mission Systems

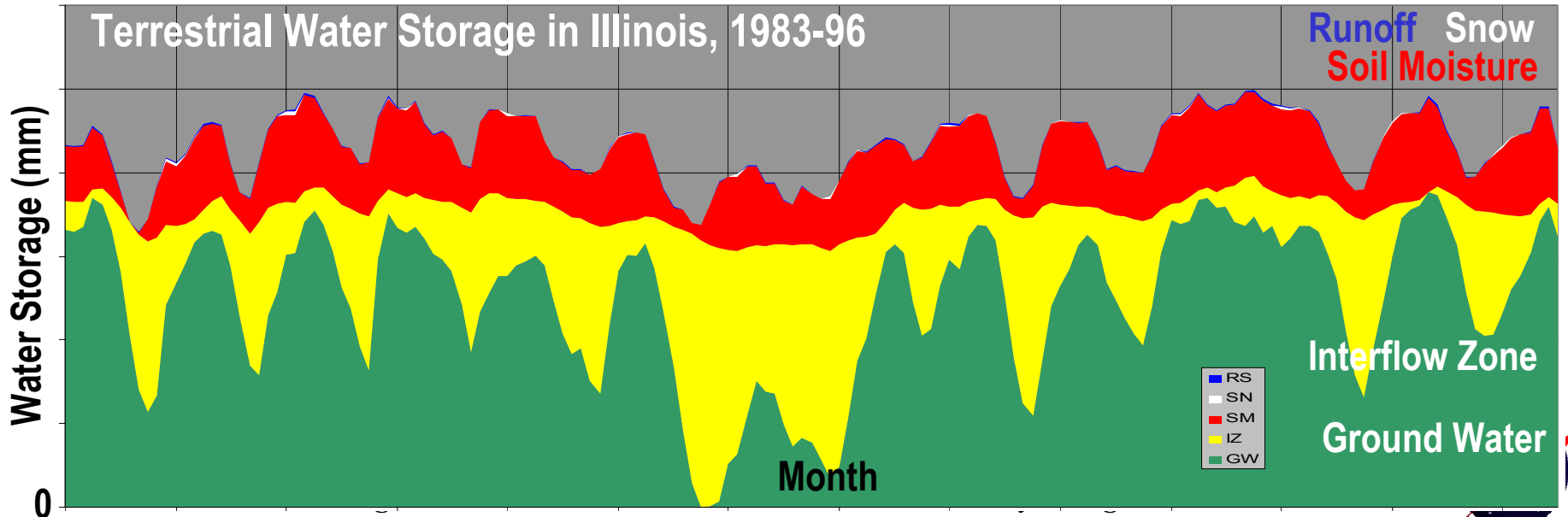
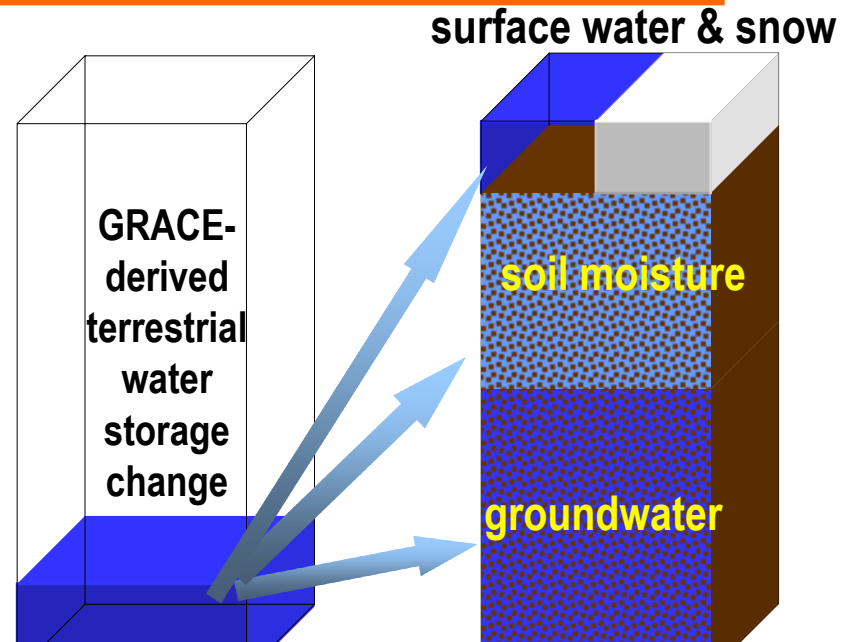
Instruments

- KBR (JPL/SSL)
- ACC (ONERA)
- SCA (DTU)
- GPS (JPL)

Satellite (JPL/DSS)
Launcher (DLR/Eurokot)
Operations (DLR/GSOC)
Science (CSR/JPL/GFZ)

Orbit

Launch: November 2001
Altitude: 485 km
Inclination: 89 deg
Eccentricity: ~0.001
Lifetime: 5 years
Non-Repeat Ground Track
Earth Pointed, 3-Axis Stable



LIS as a testbed for HEPEx

- Ensembles
 - Initial conditions
 - Physics
 - Forcing
 - Parameters
 - **NEED:** Long-term retrospective run to establish PDFs
 - **NEED:** Hydrologic models
 - **NEED:** Ensemble Calibration
- Assimilation
 - Soil Moisture, Snow, Temperature, Total Water Storage
 - Constrains the ensemble IC's
 - **NEED:** How ensembles above could be used in EnKF
 - **NEED:** Error characterization

LIS CODE and DATA at

<http://lis.gsfc.nasa.gov>

