Workshop on Land Surface Modeling in Support of NWP and sub-seasonal climate prediction

KIAPS
KOREA INSTITUTE OF ATMOSPHERIC PREDICTION SYSTEMS

Current Status of Land Surface Model in KIAPS-GM

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Outline

- LSM for KIAPS-GM
  - structure, main module
- Ancillaries for KIAPS-GM
  - grid conversion
  - structure
- Preliminary results from off-line/on-line tests
- Future plan

LSM for KIAPS-GM

- The **land surface model (LSM)** in numerical weather prediction or climate general circulation model is important for many reasons ...(Pedro 2002, ECMWF)

  - The sensible and latent heat fluxes at the surface are the **lower boundary conditions** for the energy and moisture equations in the atmosphere

  - LSM are largely responsible for the quality of model produced near surface weather

- The **Noah LSM** is chosen for KIAPS-GM because …

  - Its performance have been studied extensively including GSWP (Global Soil Wetness Project, Dirmeyer et al. 2006), GLDAS (Global Land Data Assimilation System, Rodell et al. 2004)

  - It is implemented in NCEP GFS, WRF, GRIMs and used as default LSM

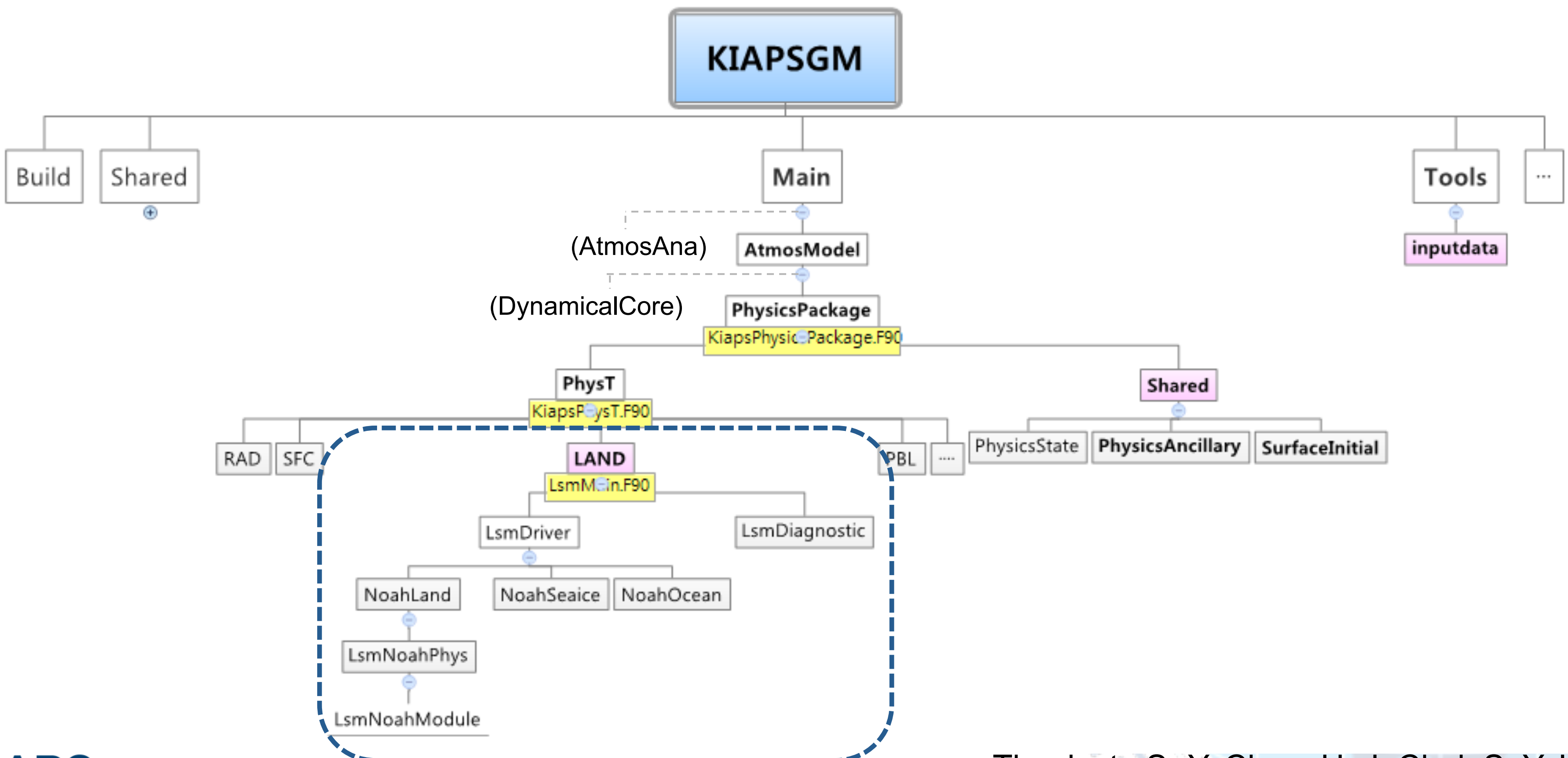
  - It has been developed continuously by many research groups/communities

* GRIMs (Global/Regional Integrated Model System (Hong et al. 2013)

Structure: Noah LSM

- The **source codes** of Noah LSM (maybe vn.2.5~2.7) are extracted from the GRIMs (Hong et al., 2013)

- It is implemented in the KIAPS-GM following the coupling strategy



Thanks to S.-Y. Chun, H. J. Choi, S. Y. Kim

Main Module

- LSM main module

```fortran
MODULE LsmMain

  USE KiapsBase, ONLY: i4=>KGM_INT_KIND, r8=>KGM_REAL8_KIND
  USE Dimensions, ONLY: np, nelemd, nlev, nsoil
  USE KiapsParallel, ONLY: KGM_Par

  USE PhysicsAncillary, ONLY: sigmaf, shdmin, snoalb, tg3,      &
                              vegtyp, soiltyp, slptyp
  USE SurfaceInitial, ONLY: z0cm=>znt
  USE SfcMain, ONLY: wspd, ech, ecm, efm, efh, efm10, efh2
  USE RadMain, ONLY: sfcdlw, sfcdsw, sfcnsw, sfalb

  USE LsmDriver, ONLY: NoahDriver
  USE LsmDiag, ONLY: LsmDiagnostic
  USE PhysicsConstants, ONLY: CPAIR, LATVAP
```

Ini (Set) Run

```fortran
  SUBROUTINE Ini

    IMPLICIT NONE

    INTEGER(KIND=i4) :: l_ierr

    pcols = np*np*nelemd
    pver = nlev

    ALLOCATE(evap(pcols))
    ALLOCATE(hflx(pcols))
    ALLOCATE(latentheat(pcols))
    ALLOCATE(sensibleheat(pcols))
```

```fortran
    evap         = 0.
    hflx         = 0.
    latentheat   = 0.
    sensibleheat = 0.
    gflx         = 0.
    edir         = 0.
    ec           = 0.
    ett          = 0.
    snowev       = 0.
    snowmt       = 0.
```

```fortran
!-----------------------------------------------------------------------------
  SUBROUTINE Run ( dtime, slimsk, zmid, tmid, qv, pmid, umid, vmid, psfc, tsfc,&
                   canopy, stsoil, smsoil, slsoil, snowh, snoweq,               &
                   prcp,  snowc, rc )
```

```fortran
!-----------------------------------------------------------------------------
! Run Noah LSM
!-----------------------------------------------------------------------------

    CALL NoahDriver                                                             &
! In/Env
       ( pcols, nsoil,  dtime, inistp, slimsk, srflag,                          &
! In/Forcings
         sfcdlw, sfcdsw,  sfcnsw,   prcp,  zmid0, tmid0,    qv0,  pmid0,    psfc,&
           wspd,    ech,    ecm,  sfalb,                                         &
! In/Paramter
         vegtyp,soiltyp, slptyp,   z0cm, sigmaf, shdmin, snoalb,    tg3,         &
! In/Out
           tsfc, canopy, stsoil, smsoil, slsoil,  snowh, snoweq,                 &
! Out
           evap,   hflx,   gflx,   edir,     ec,    ett,  snowc, snowev,         &
         snowmt, snowfl,   ep1d,  runof,  drain,   qsfc,  evapc,    rho,         &
             rc )
```

```fortran
!-----------------------------------------------------------------------------
! Run diagnostics
!-----------------------------------------------------------------------------

    IF(KGM_Par%isMasterProc) print*,'run LAND_Diag....'

    CALL LsmDiagnostic                                                          &
! IN
       ( pcols, sfcdlw, sfcnsw, umid0, vmid0, tmid0,   qv0, pmid0,              &
           psfc,   tsfc,   qsfc,  evap,   efm,   efh, efm10,  efh2,             &
! Out
           u10m,   v10m,    t2m,   q2m,  rnet )

    IF(KGM_Par%isMasterProc) print*,'run LAND_Diag....done'
```

Fin

```fortran
!
  SUBROUTINE Fin

    IMPLICIT NONE

    DEALLOCATE(evap)
    DEALLOCATE(hflx)
    DEALLOCATE(latentheat)
    DEALLOCATE(sensibleheat)
```

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Ancillaries for KIAPS-GM

- The **key inputs** to the Noah LSM are

  - Vegetation type
  - Soil type
  - Secondary parameters which can be specified as function of vegetation/soil types
  - General parameters used in the LSM

- For the Noah LSM in the KIAPS-GM, the **SiB dataset** from the NCEP (NCEP CPPA/GAPP web site) is used, which has **13-category vegetation type** and **9-category soil type**, respectively

- Most of the secondary parameters are **prescribed as table** in the source code, while some can be specified as **spatial (temporal) 2-D fields**.

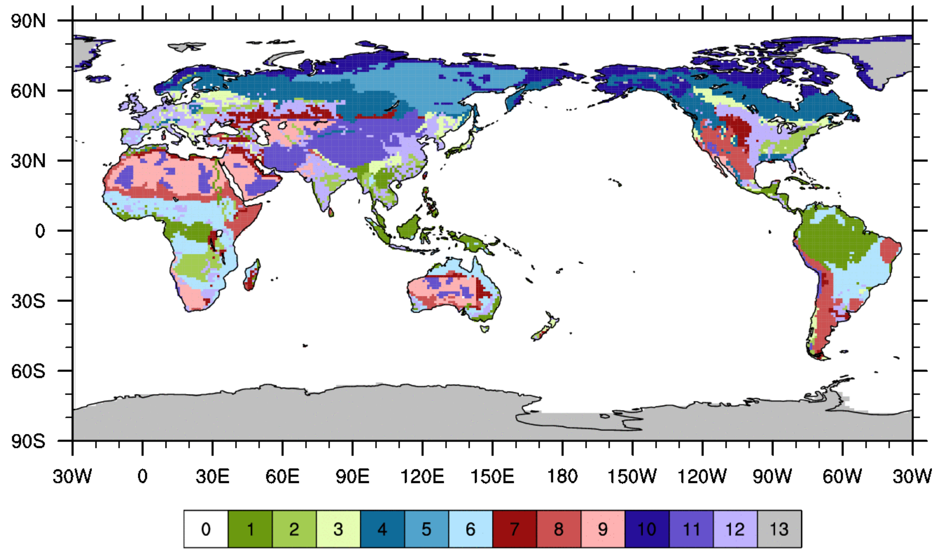
* Vegetation parameters:
Number of root layer
Min. stomatal resistance
Snow depth threshold
Roughness length
…
* Soil parameters:
Max. soil moisture
Saturation soil conductivity
Soil quartz content
…

* Spatial (Temporal) parameters:

Green veg. fraction
Albedo
Max. snow albedo
Deep soil temp.

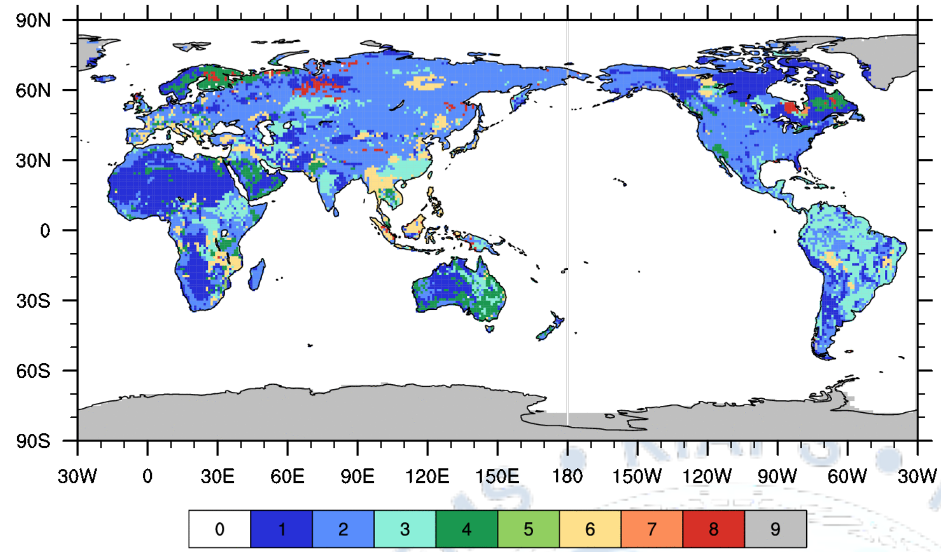
Vegetation/soil type

Vegetation type (1-deg)



0: ocean/water
1: Broadleaf-evergreen trees
2: Broadleafd-eciduous trees
3: Broadleaf and needleleaf trees
4: Needleleaf-evergreen trees
5: Needleleaf-deciduous trees
6: Broadleaf trees with groundcover
7: Groundcover only
8: Broadleaf shrubs with perennial groundcover
9: Broadleaf shrubs with bare soil
10: Dwarf trees and shrubs with groundcover
11: Bare soil
12: Cultivations
13: Glacial

Soil type (1-deg)



0: ocean/water
1: loamy sand
2: silty clay loam
3: light clay
4: sandy loam
5: sandy clay
6: clay loam
7: sandy clay loam
8: loam
9: glacial

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Grid conversion

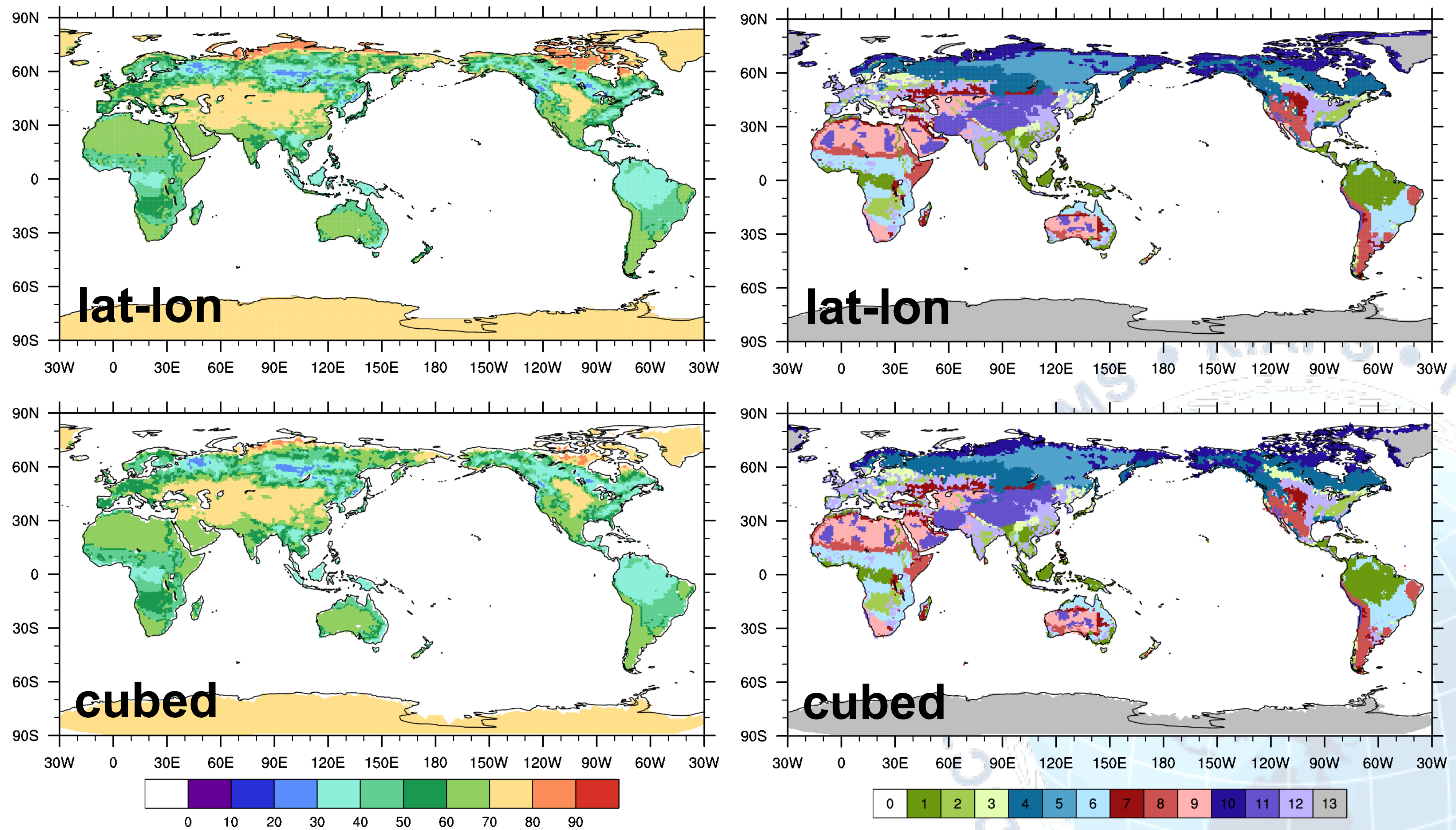
- Because the KIAPS-GM is developed based on the cubed sphere, the ancillary data on lat-lon grid **should be re-defined on the cubed sphere grid**.
- Lat-lon grid data is simply converted into the cubed sphere using the **SCRIP conservative remapping method** for most of parameters and **maximum weighting method** for the index type parameters (i.e., vegetation and soil type, land-sea mask, land fraction).

NCEP CPPA/GAPP web site: surface fields

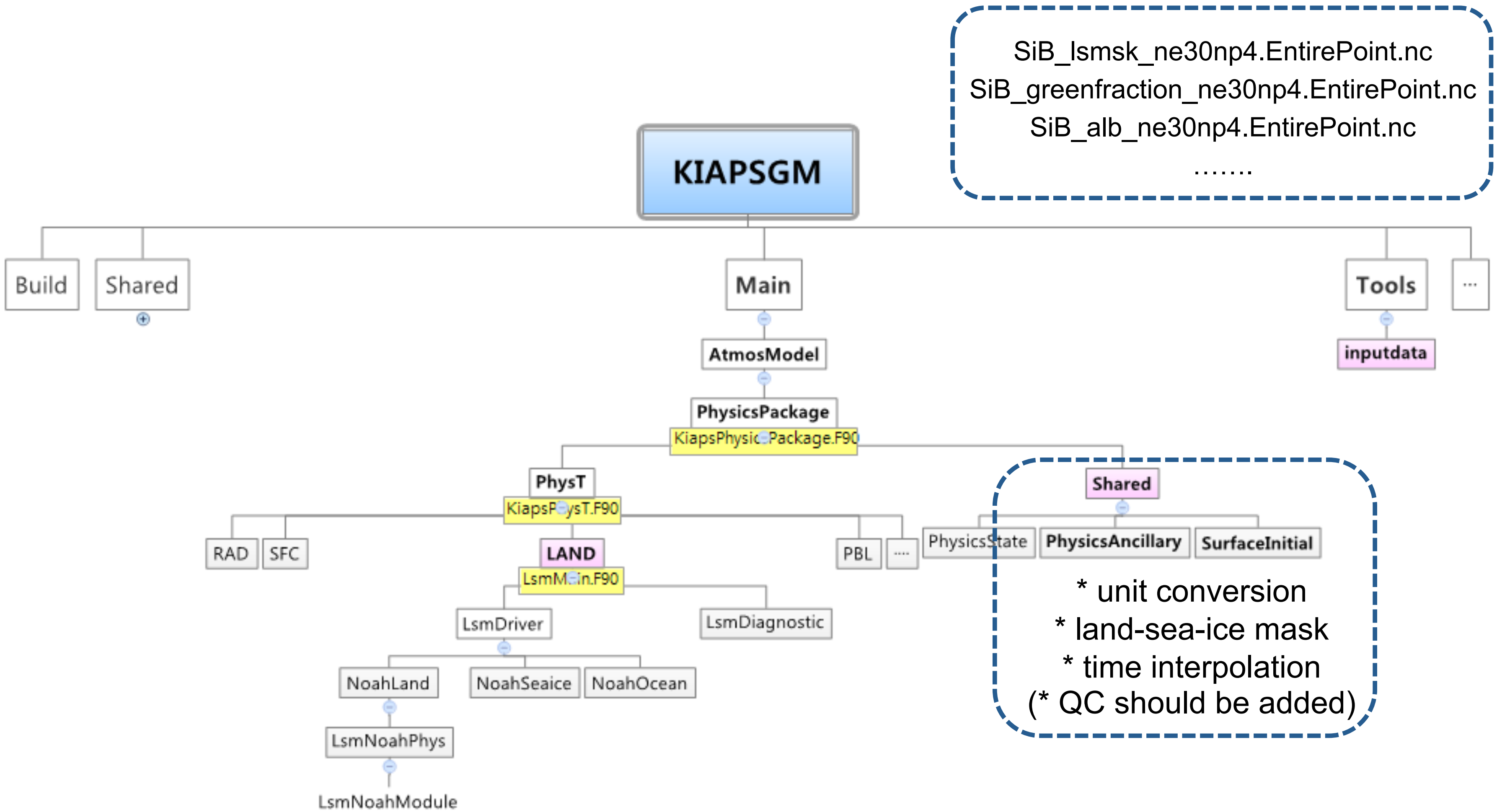
Variable	Unit	Resolution	Source	Reference
Vegetation type	index	1°x1°	SiB 13-type (GFS) Kuchler 32-vtype (1983), Matthew land-use (1984,1985)	Dorman and Sellers (1989)
Soil type	index	1°x1°	SiB 9-type (GFS) FAO soil map (1974), Matthew veg (1983,1984)	Staub and Rosenzweig (1987)
Slope type	index	1°x1°	islope (GFS)	Zobler (1986)
Deep soil temp	K	1°x1°	GRIMs ancillary data	Hong et al. (2013)
Green veg. fraction	%	0.144°x0.144° monthly	NOAA/AVHRR NDVI 5-yr clim. data (1985-1987, 1989-1991) (GFS)	Gutman and Ignatov (1977)
Min. green veg. fraction	%	0.144°x0.144° monthly	NOAA/AVHRR NDVI 5-yr clim. data (1985-1987, 1989-1991) (GFS)	Gutman and Ignatov (1977)
Max. snow albedo	%	1°x1°	Defense Meteorological Satellite program winter of 1978-1979 (GFS)	Robinson and Kukla (1985)
Albedo	%	0.144°x0.144° monthly	NOAA/AVHRR Green Vegetation Index (1985-1989)	Csiszar and Gutman (1999)

Example

Maximum snow albedo (%) / Vegetation type (Index)



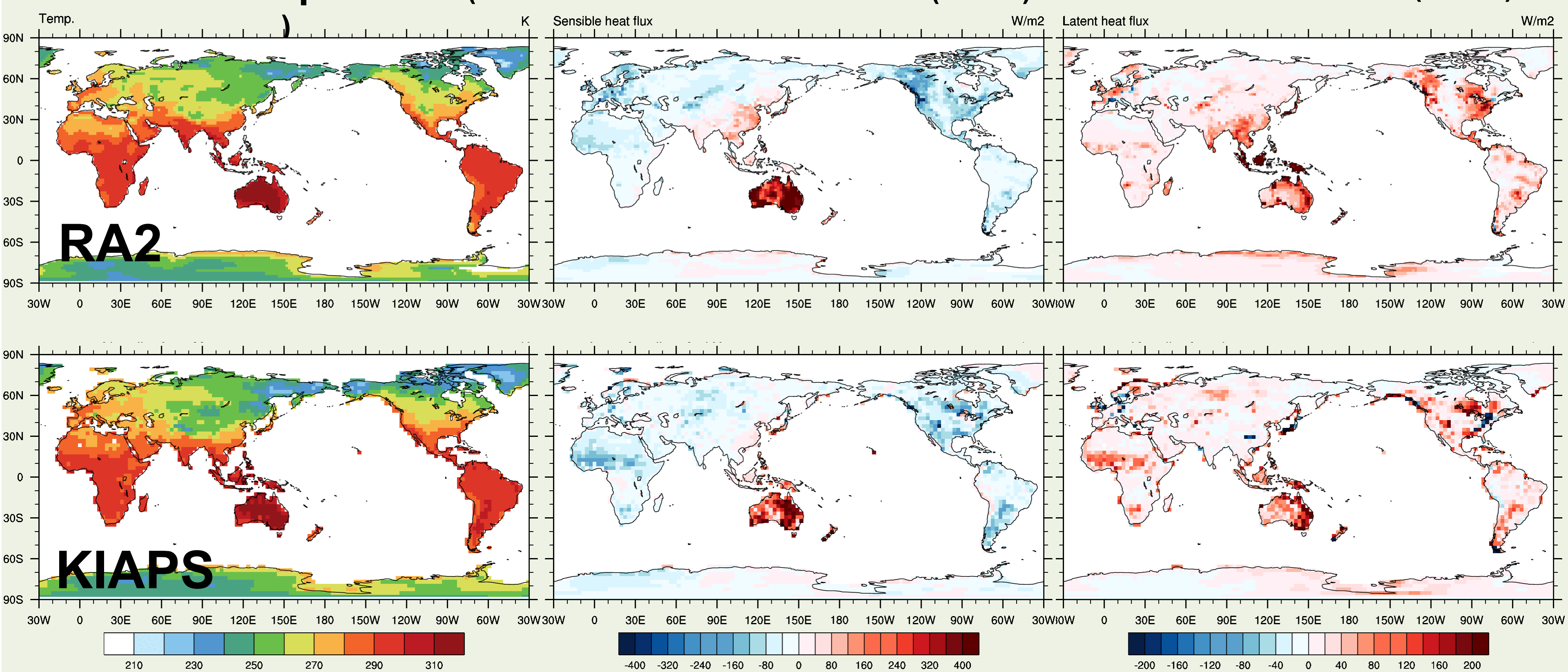
Structure: Ancillaries



Off-line test

- Model version : KIAPSGM Physics only
- Resolution : ne30np4, 70 levels
- Period : 00Z01Jan2012 ~ 00Z02Jan2012, 6-hourly time-step
- Dynamic forcing: ERA-Interim for the simulation period
- Surface Initial : ERA-Interim, HadISST SST and Sea-ice (monthly climatology)

Surface temperature (K) **Sensible heat flux ($W\ m^{-2}$)** **Latent heat flux ($W\ m^{-2}$)**



On-line test

- Model version : KIAPS-GM
- Resolution : ne30np4, 70 levels
- Period : 00Z01Jan2012 ~ 00116Jan2012
- Delta-t : 1 min.
- Initial data : ERA-Interim
- External forcing : HadISST SST and Sea-ice (monthly climatology)

On-line test: 15-day mean

2m Temperature | **2m Specific Humidity**

ERA-Interim

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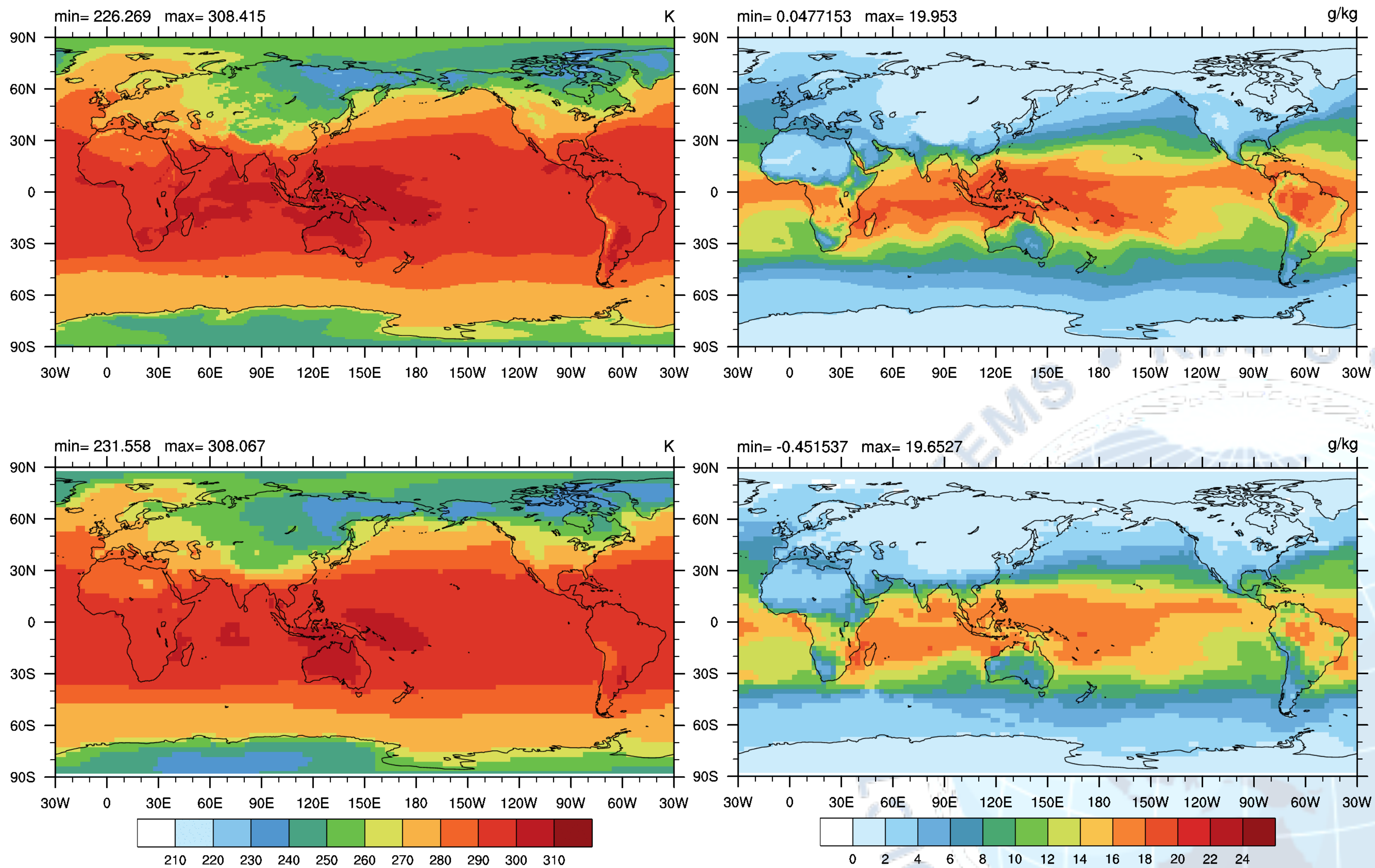
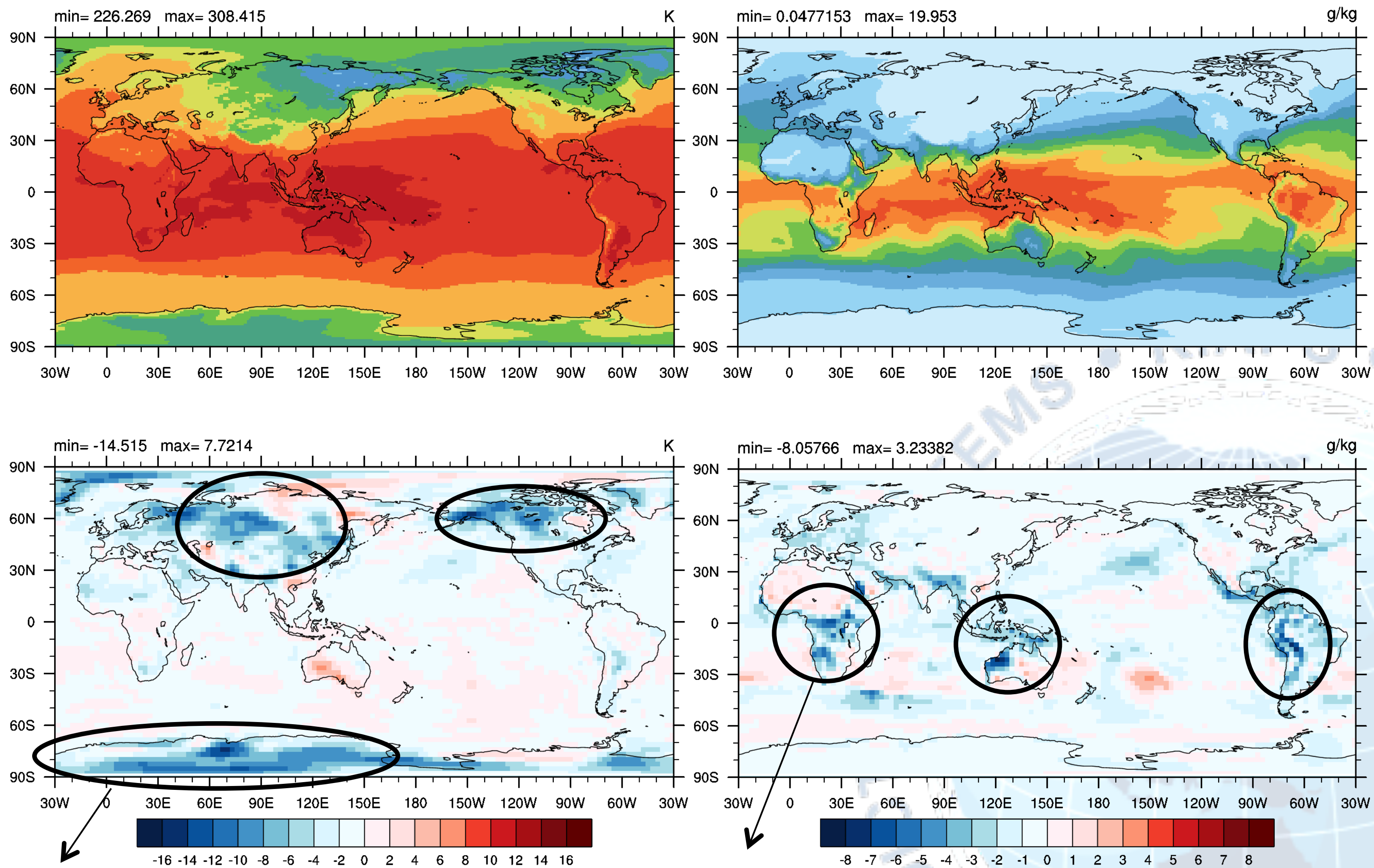


On-line test: 15-day mean

2m Temperature | 2m Specific Humidity

ERA-Interim

KIAPS - ERA



colder

drier

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On-line test: 15-day mean

Latent Heat Flux | **Sensible Heat Flux**

ERA-Interim

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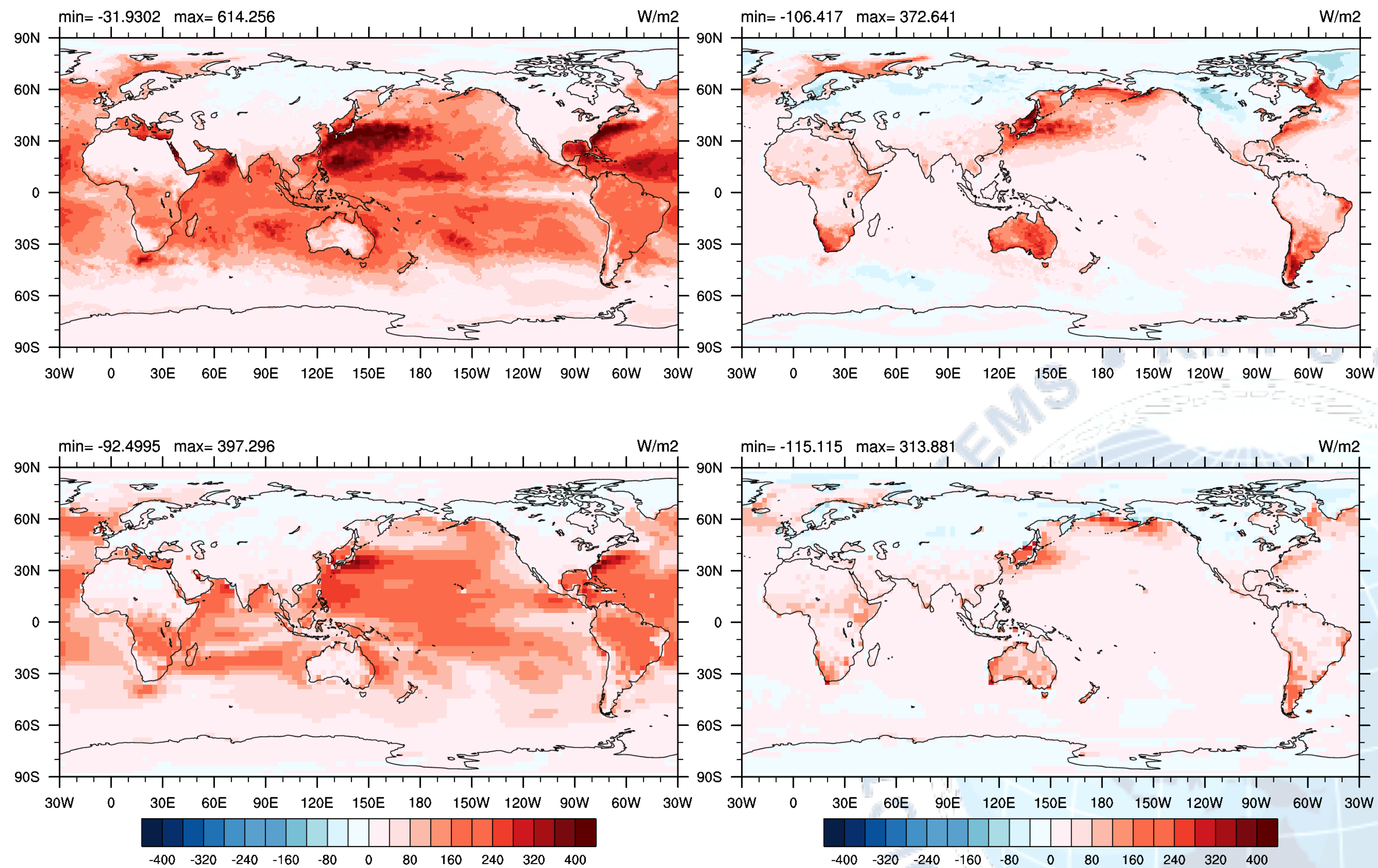
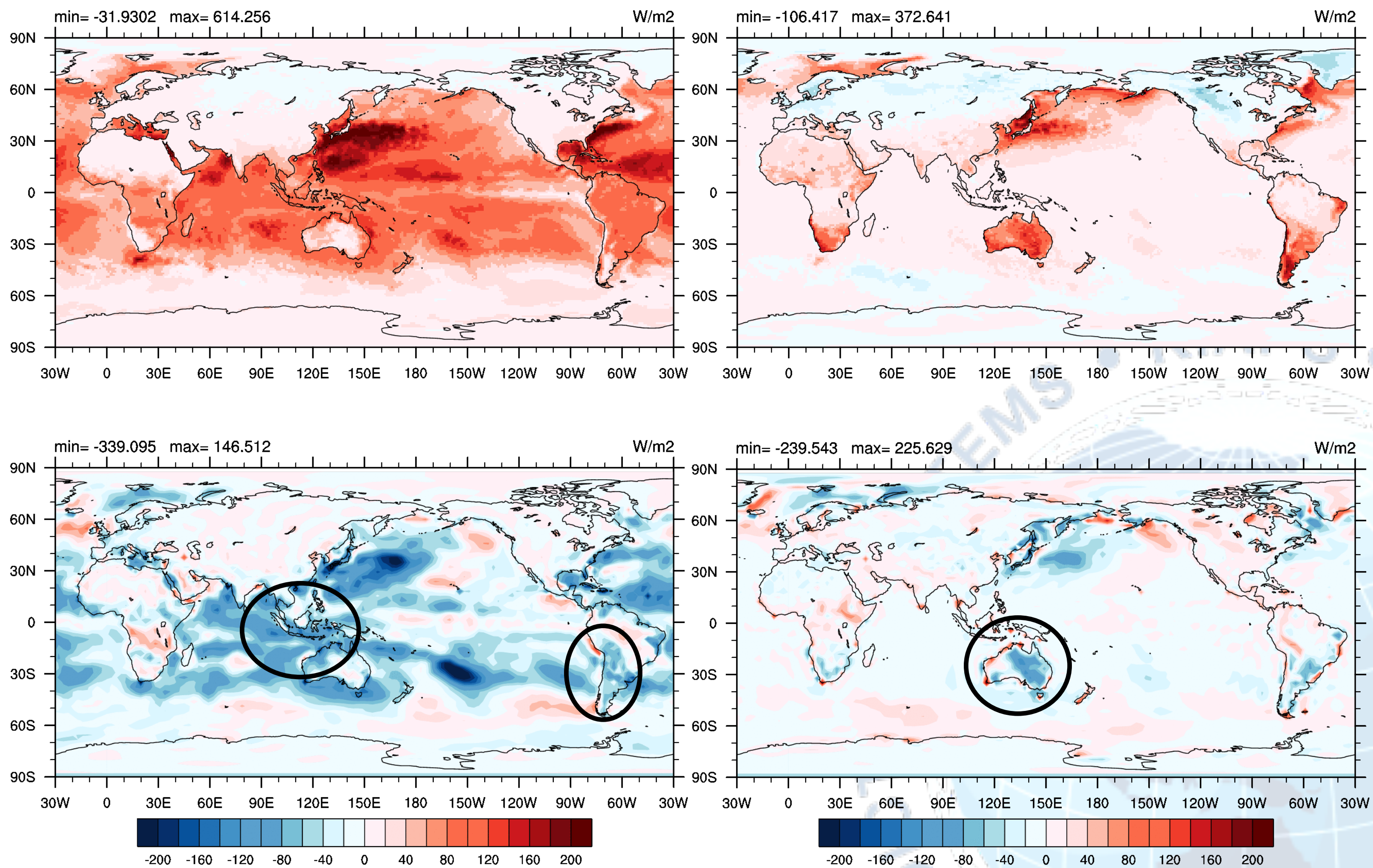


On-line test: 15-day mean

	Latent Heat Flux	Sensible Heat Flux
ERA-Interim		
KIAPS - ERA		



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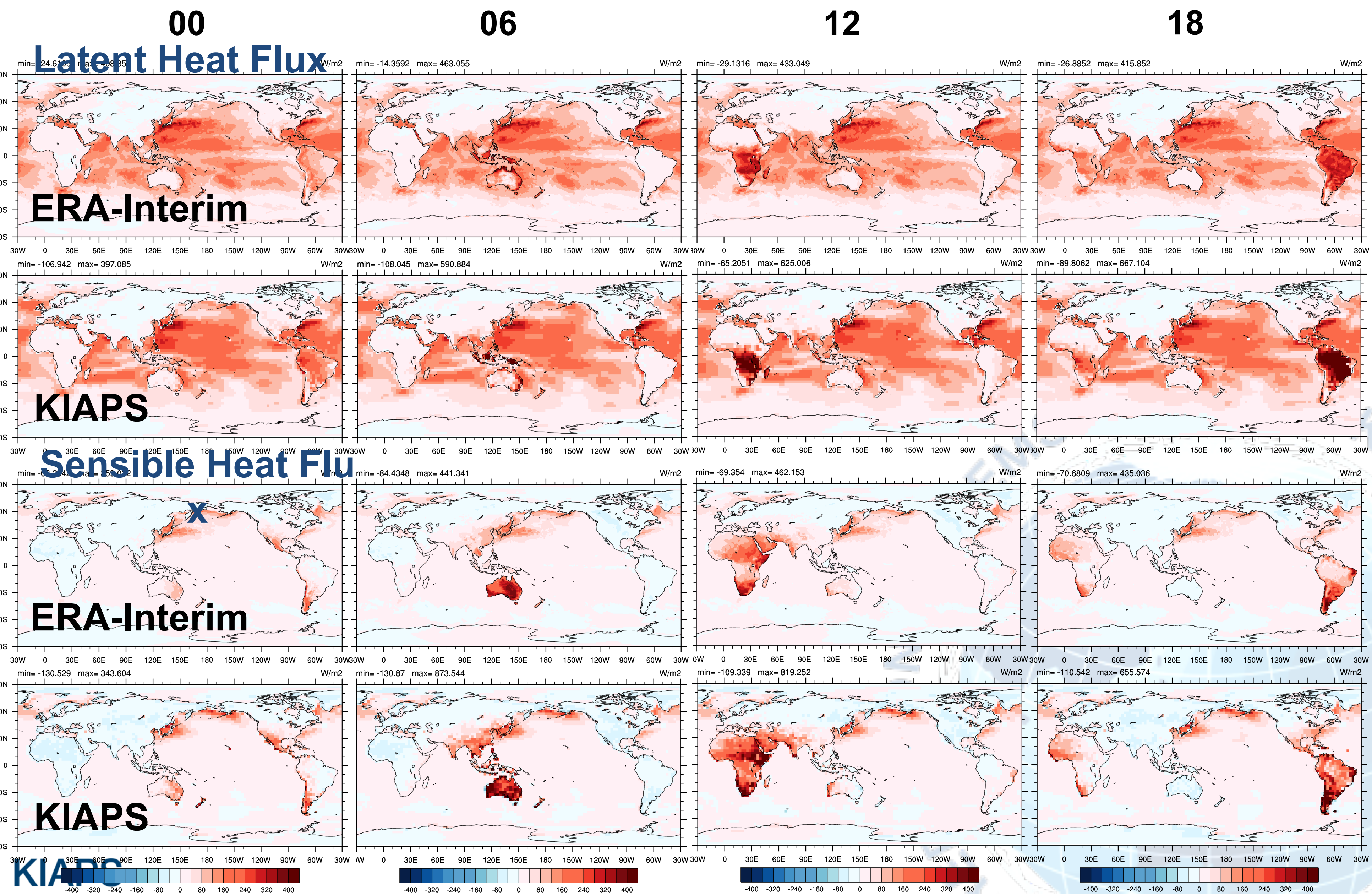
On-line test: 15-day mean



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Future plan

- Evaluation of ensemble experiment
  - Climatology, seasonal cycle, monthly variation
  - Energy and water balance at the surface
- Evaluation of AMIP-type experiment

→ To find deficits of Noah LSM coupled in the KIAPS-GM

- Sensitivity experiment with high-resolution vegetation/soil parameters based on the cubed sphere (provide by Dr. Guo)

Thank you