

GRACE Follow-On Project



Science Data System (SDS)

1: 'GrandSim' update

2: Changes from GRACE-FO vs GRACE

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October 10, 2017



What is the “Grand Simulation” (Grand Sim)?



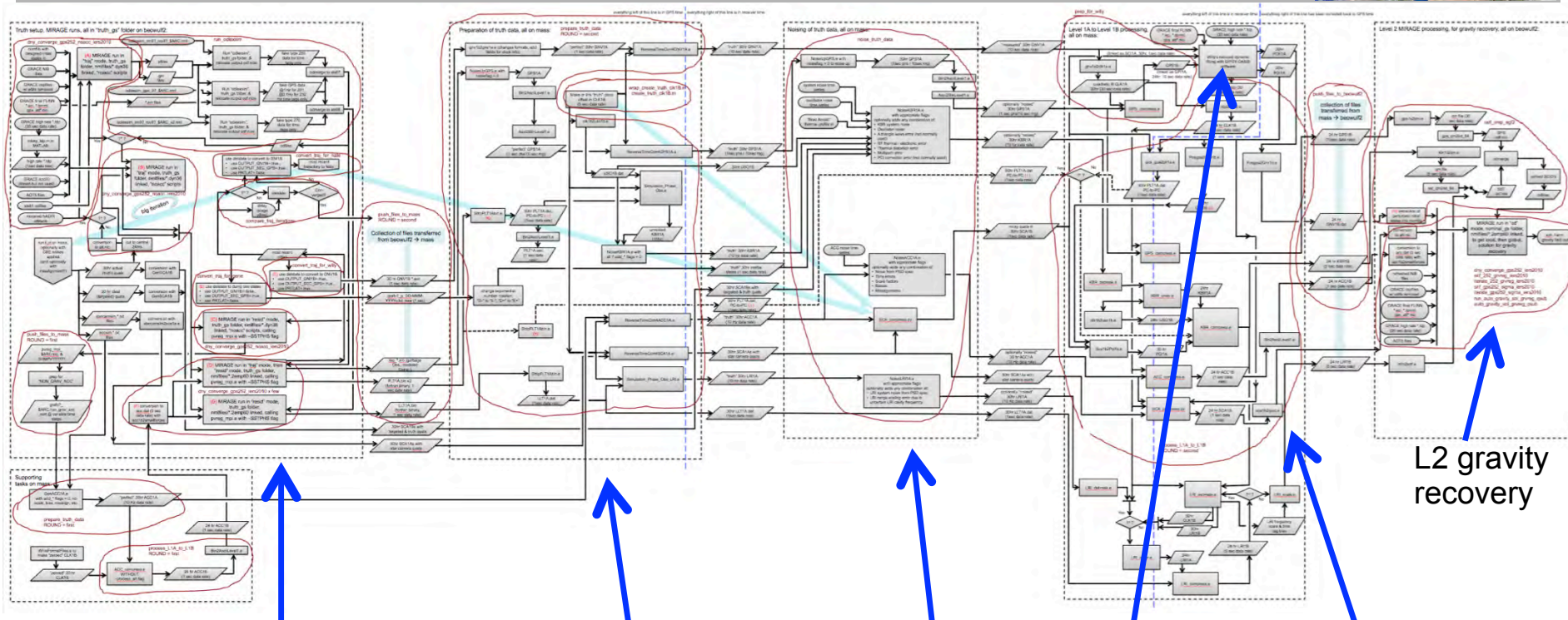
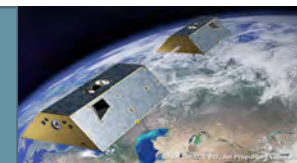
SDS team has performed an overall system test to:

- demonstrate effective implementation and inter-operation of as much as possible of SDS software for Level 1-3 data processing.
- provide a *Verification and Validation* tool for all core SDS *software functions*
- recover a truth Earth gravity field to within top-level requirements, given measurement noise models only.
 - Top level GRACE-FO geoid error requirement is written in terms of measurement noise sources only
 - Non-measurement noise sources maybe improved over time (.e.g. GPS orbits/clocks, de-aliasing, tides ..)
 - Users of Grand Sim data should expect larger gravity recovery errors due different background models, geophysical models and GPS orbits & clocks

First ever Earth gravity recovery simulation that includes the full level 1 processing chain.



Snapshot of Overall Process



L2 truth models generate mutually consistent truth orbits, non-gravitational acceleration and attitude time histories

Make L1A data products, apply realistic clock offset

Degrade L1A data products with CBE noise models

Perform L1 POD & clock offset recovery

L1A to L1B processing: do clock correction, form DOWR, compression

L2 gravity recovery



Current SDS 'Grand Sim' status:



- Successful Grand Sim runs have been completed for the first true end-to-end simulations
- Grand Sim proved to be a powerful tool to look at individual sources of error and their impact on gravity retrieval
 - New insights have been gained, in particular on Level-1 data processing effects on gravity errors
- SDS is working on finalizing SDS Grand Sim L1B data files and gravity recovery results
- Full release of Grand Sim data expected by Fall AGU



GRACE Follow-On Project



Notice of Science Data System product changes GRACE-FO vs GRACE

October 10-12, 2017



GRACE Science Team Meeting, Austin Texas, 10 October 2017
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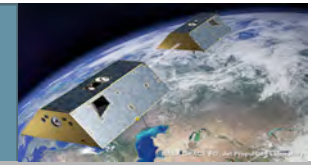
Introduction



- GRACE-FO Science Data System objective:
 - retain as much as possible the GRACE formats, contents and filenames.
- New NASA data standards and archiving requirements apply to GRACE-FO
 - GRACE data formats have been submitted to be a NASA data standard
 - New NASA archive standards require meta data. Some of the meta data is available in GRACE L1 data but not readable by archive tool. YAML formatting of the L1 headers was chosen to fulfill readability requirement.
 - YAML headers also to be added to Level-2 products (minor)
- The list of changes presented here may not to be final.
- A “GRACE-FO Level 1 Data Product User Handbook” document, detailing the data product formats, will be available soon.
- The changes in this presentation are in reference to the GRACE data product formats as described in “GRACE Level 1B Data Product User Handbook,” March 24, 2010 by K. Case, G. Kruizinga, and S. Wu



Level-1: Changes



- Level 1A products will be released in addition to Level 1B
- Only ASCII, **not binary**, versions of products will be released
- New YAML header format (data records unchanged). A (draft) sample:

```
# Example of proposed ascii format for GRACE L1B dataset with YAML style.
# example file: ACC1B_2003-01-03_A_02.asc
# Begin of Header
```

```
Header :
  dimensions:
    num_records : 86400

  project_attributes:
    time_epoch      : '2000-01-01T12:00:00.00'
    start_time_pass_epoch : '94823940.000000 (2003-01-02T23:59:00.00)'
    stop_time_pass_epoch  : '94910460.000000 (2003-01-04T00:01:00.00)'
    software_version      : 'ACC_compress.c, v1.77'
    software_linktime     : '2009-06-11T17:35:36'
    input_file : # col1. To_File, col2. Filename, col3. File_Tage
      - ['ACC1A', 'ACC1A_2014-01-09_A_02.dat', '2014-01-10 03:41']
      - ['CLK1B', 'CLK1B_2014-01-09_A_02.dat', '2014-01-22 18:37']

  global_attributes:
    title      : 'GRACE Accelerometer Level 1B product'
    summary    : 'JPL GRACE Accelerometer level 1B (ACC) linear and angular acceleration components of each spacecraft. Detailed information in the GRACE handbook v1.3'
    keywords   : 'GRACE-A, Level-1B, ACC'
    keywords_vocabulary : 'NASA Global Change Master Directory'
    conventions : 'CF-1.6, ACDD-1.3, ISO 8601'
    id         : 'ipACC1BF'
    uuid       : 'TBD'
    naming_authority : 'GRACE Tellus'
    history    : 'GRACE-A Level-1B Accelerometer Data'
    platform   : 'GRACE-A'
    instrument : 'Accelerometer'
    processing_level : 'Level-1B'
```

Header contains
data content
description



```
acl_z_res :
  long_name : 'Linear acceleration along z-axis residual with fit'
  units : 'm/s2'
  coverage_content_type : 'modelResult'
  data_type : 'double precision'
  comment : '11th column'

qual_flg :
  long_name : 'Data quality flag'
  coverage_content_type : 'qualityInformation'
  data_type : 'unsigned character'
  flag_masks : [0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b]
  flag_meanings :
    - 'bit 0 = Proof mass voltage out of nominal range'
    - 'bit 1 = Not Defined'
    - 'bit 2 = residual > 10 microns/s2'
    - 'bit 3 = extrapolated clock correction >5s but < 15s from fit center'
    - 'bit 4 = bit 0 = extrapolated clock correction < 5s from fit center'
    - 'bit 5 = filled data > 15s from fit center'
    - 'bit 6 = filled data > 5s but < 15s from fit center'
    - 'bit 7 = filled data < 5s from fit center'
  comment : '12th column'

# End of Header
```



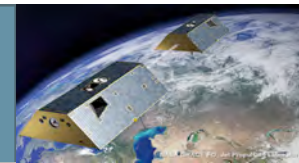
Level-1: Changes (cont.)



- New product types introduced for GRACE-FO:
 - LRI (laser ranging) science and housekeeping products
 - GNI1B: orbit solution in inertial frame (vs. GNV1B orbit solution in Earth-fixed frame)
 - IMU1B: IMU data
- A few GRACE Level 1B products will be retired: QKS1B, QSB1B
- Changes in meaning (NOT format) of quality and product flags in data records
 - Some products will have more quality flags defined, which were previously marked as undefined in GRACE: GNV1B, GPS1B, IHK1B, MAG1B, MAS1B, TIM1B
 - Some products may have more product flags defined, which mean additional data field(s) will be present: TNK1B
 - Changes in meanings of quality flags: KBR1B



Level-2

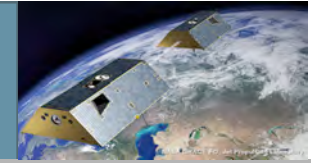


- Same “GSM” format as GRACE products
- Format of filename will stay the same – meaning of the individual strings will change.
- New changes will accommodate:
 - Name of mission
 - Type of solution (MWI/LRI/combined, regularized, daily, etc.)
- Header information in the GSM-file will be in YAML format
 - Significantly more metadata
- **Any scripts that use information in existing header or filename will likely need to be modified!**



Changes from AOD1B RL05 to RL06

[Dobslaw et al., GFZ]



RL05	RL06
since 1979; 6 hourly; d/o=100	since 1976; 3 hourly; d/o=180
ERA-Interim (1979 – 2000) op. ECMWF (since 2001)	ERA-40 (1976 – 1978) ERA-Interim (1979 – 2006) op. ECMWF (since 2007)
OMCT 1.0° forced with 6 hourly ECMWF data	MPIOM TP1L40 forced with 3 hourly ECMWF data
ATM; OCN; GLO; OBA	ATM (IB-corrected); OCN (additive inverse IB-corrected); GLO; OBA
S2 tide removed from OCN only; S2 and S3 partially aliased	12 frequencies removed from OCN and ATM
artificial drift in OCN component; jumps in ATM component	residual decadal signals are in range of observed variability
update cycle: weekly	update cycle: daily



GRACE-FO Level-3 SDS Requirements



GRACE: had no project supported Level-3
GRACE Follow-On: Level-3 part of the Project Science Data System

L3-SDS-65:

- The SDS shall develop the capability to produce a Level-3 science product consisting of a monthly gridded, area averaged map of equivalent water height derived from the monthly Level-2 gravity solution.

L3-SDS-79:

- The SDS shall distribute Quick-Look Level-3 data to the science community within 3 days of ground data collection.



EARTH'S WATER CYCLE

● Storage ● Flow

● Freshwater in glaciers and snow

● Surface runoff

● Freshwater in lakes and rivers

● Groundwater storage

● Soil moisture

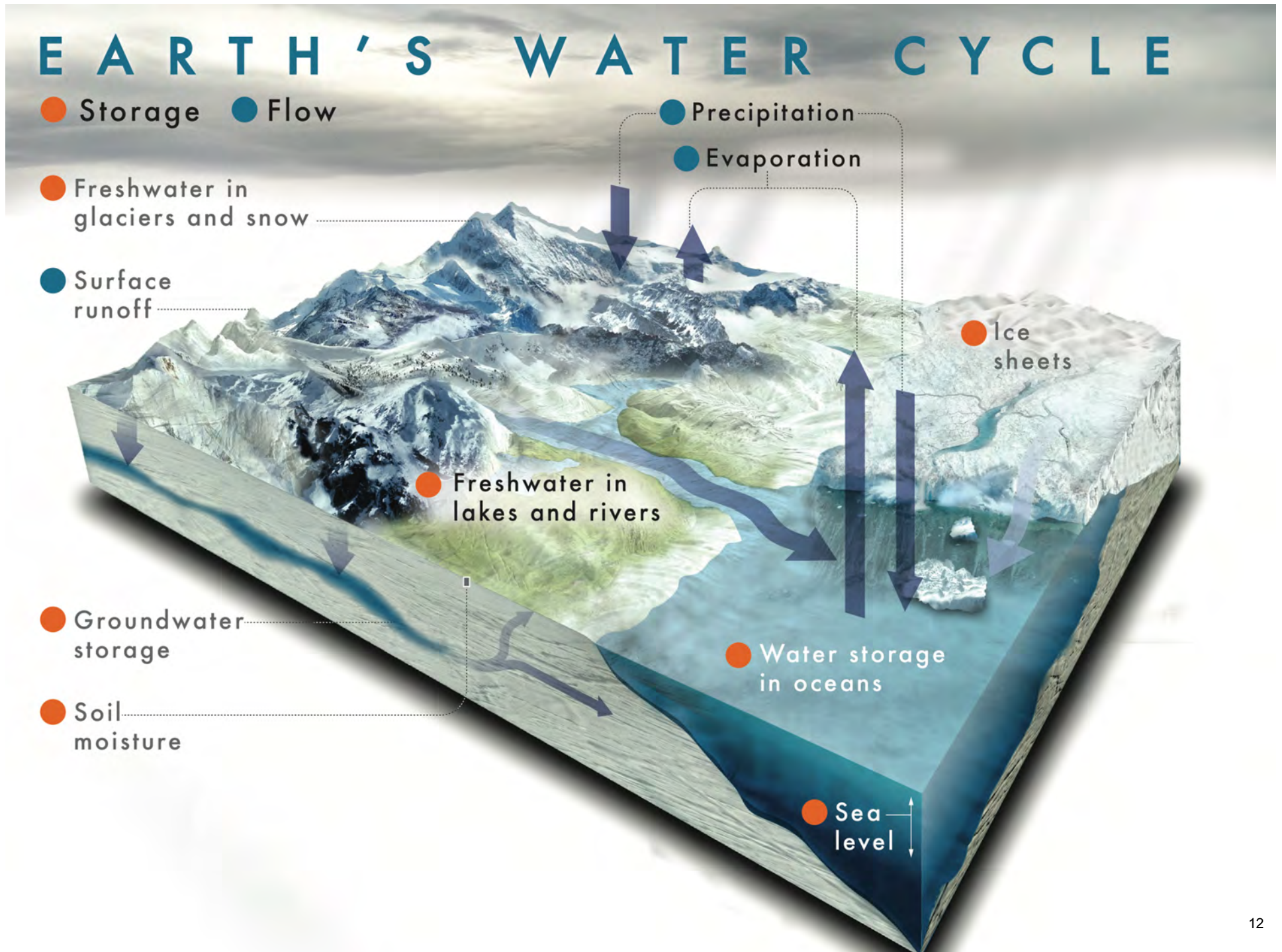
● Precipitation

● Evaporation

● Ice sheets

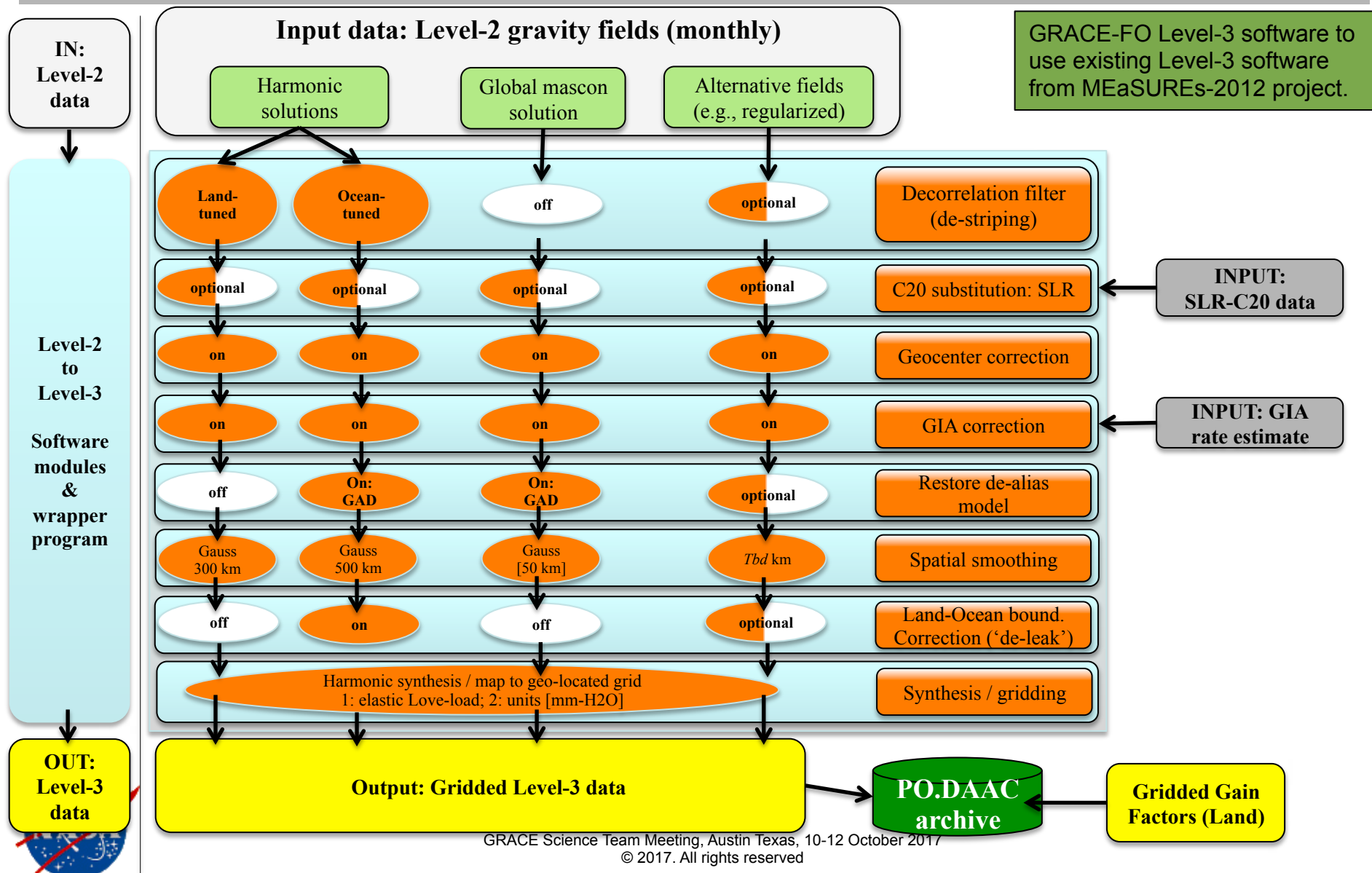
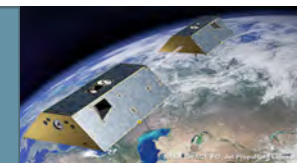
● Water storage in oceans

● Sea level



GRACE-FO: Level-3 Design Architecture

(mostly current MEaSUREs heritage [i.e., Tellus products])



Quick-Look (QL) Level-3 products



Need & Relevance:

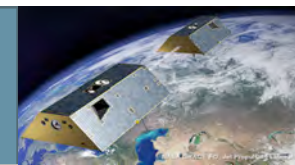
- ***lower latency**** hydrology applications like regional drought or flood monitoring & prediction (e.g., National Drought Monitor)
- CSR leads development and production of Level-2 QL fields

****Lower latency:***

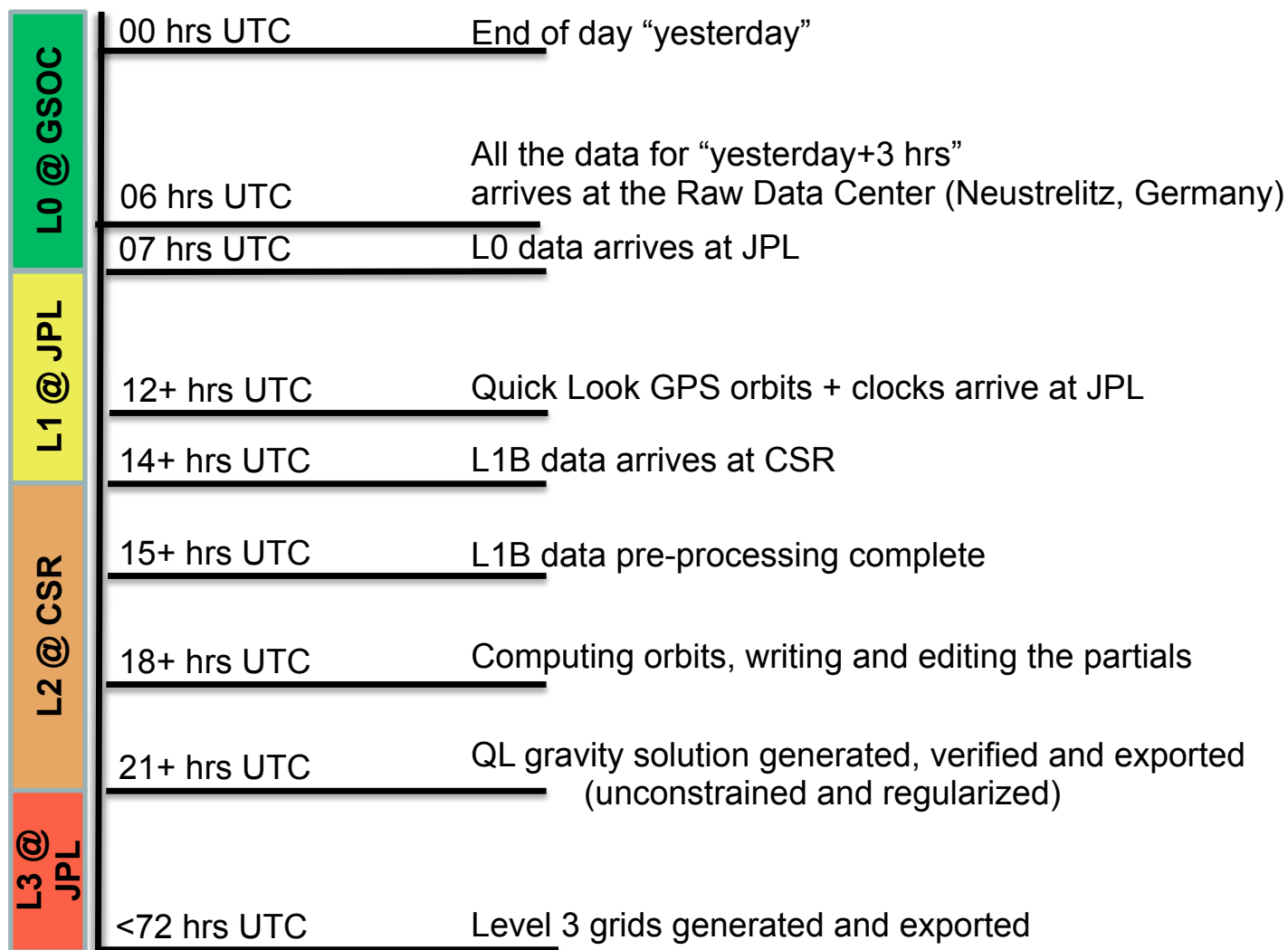
- Level-3 gridded mass anomalies, based on moving-window Level-1/Level-2 QL gravity solutions
- Update frequency: daily
- Latency: 3 days



Quick-Look Low Latency Products Time Line

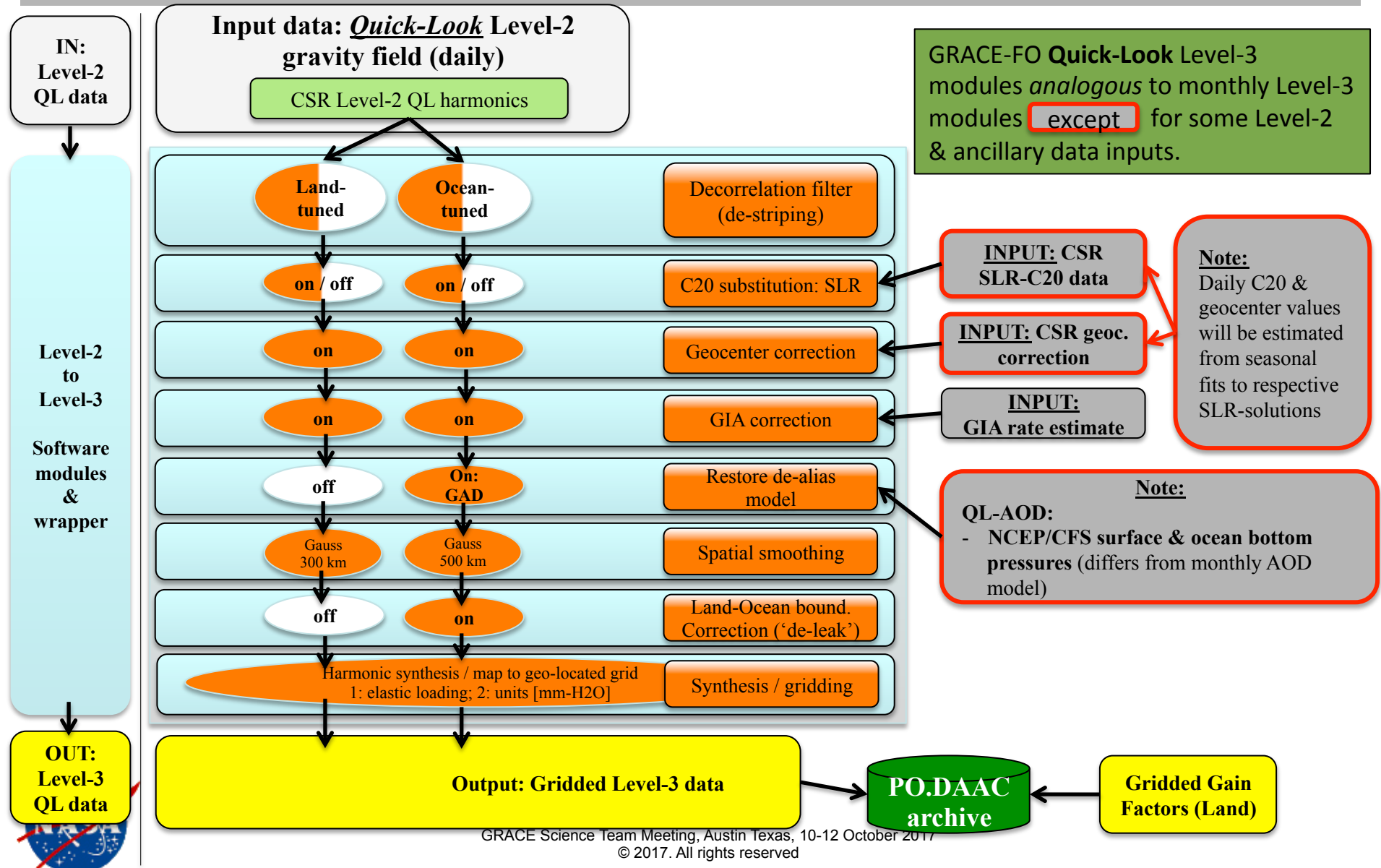
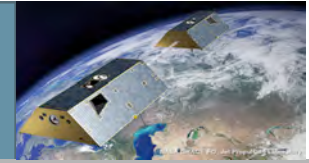


GRACE – FO Quick look data processing timeline

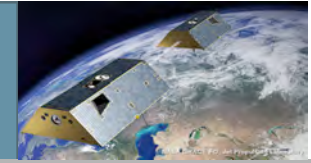


GRACE-FO: QL Level-3 Design Architecture

(mostly extend from nominal monthly solutions)



GRACE Tellus data portal



The screenshot shows the GRACE Tellus data portal website. The header includes the NASA Jet Propulsion Laboratory logo and the text "GRACE Tellus GRAVITY RECOVERY & CLIMATE EXPERIMENT". A navigation bar contains links for ADMIN, Mission, Data, Publications, Multimedia, Applications, News & Events, and About. The main content area features a large section titled "Studying Earth's Gravity" with a sub-header "GRACE Making Plans for Final Science Data Collection". Below this is a paragraph about the mission's final science collection and links for "Full Story" and "All News". To the right is an image of the GRACE satellite. Below the main section are two smaller sections: "Data Updates" with a link to "JPL Global Mascon grids through 06/2017 released!" and "Top Data Sets" with a link to "JPL Global Land / Ocean Mascons (RL05M_1.v02)".

- Tellus GRACE website initially conceived / funded through NASA MEaSUREs (2x)
- Will continue and expand this web portal going into GRACE-FO operations





- Expected launch date: March-21, 2018
 - Likely ~4-6 month gap between GRACE and GRACE-FO
- Maintain and expand our science community in the GRACE-FO era
- Main short term issues:
 - Understand and be able to use GRACE FO data as quickly as possible
 - Link G-FO data with GRACE data for long time series
 - Assess capabilities of LRI

Comments?

Questions?

Ideas?

