e Euclid WL 2p-stat meeting, Feb 4+5, 2016, IAP Paris.
See the meeting web page http://www.cosmostat.org/event/euclid-wl-2p-stat-meeting.

Place
98, bd Arago, 75014 Paris, Metro-Stations Denfert-Rochereau, St. Jacques.
Salle Entresol, lower mezzanine.

Participants

Martin Kilbinger, Alan Heavens, Justin Alsing, Tom Kitching, Karim Benabed, Andy Taylor, Sree Balan, Patrick Simon, Michael Brown, Lee Whittaker, Marika Asgari, Paniez Paykari, Jean-Luc Starck, Bertrand Morin.
Remotely: Benjamin Joachimi
Apologies: Reiko Nakajima

Archive From London

Link to Telecon where 2-point stats london splinter was discussed:

https://docs.google.com/presentation/d/1TFNX47p6gnOk_qSBOT4fyJX1YRSwq6xvtUKdQ_l37Qw/edit#slide=id.gea4aa1b45_0_19

Requirements (Th afternoon)

What do we need to calculate/produce in LE3?

Position-Ellipticity : PE, PB, PP.

At minimum shear-shear (gg) EE, EB, BB auto- + cross-correlations in tomographic z-bins.
Most likely also shear-position PE, PB, position-position PP, for IA.
Note that GC group is doing PP with photo-z's. Same principle and/or algorithm, but they might focus on (z-z) auto-correlations, whereas we need z1-z2 cross-correlations as well.

Power Spectrum/correlation function - code, and data products for both categories below

Two categories

[For power spectra - see below for where the list differs for the real-space correlation functions]

Category A) Best unbiased cosmology-insensitive estimate: (gg)

- 1) mask-corrected (i.e. on sky/all sky),
- 2) IA "nulled", for the g
- 3) Shot noise-subtracted,
- 4) Assuming linear relation between shear and intrinsic (TBD), for g
- 5) corrected "data" systematics
    - Also validation test outputs
    - Also sanity-check outputs
    - Validation test is that auto correlation gp is zero, and pp to test redshift distribution
- Motivation: Can be used by third parties for plotting and simple likelihood analysis. Should provide unbiased cosmo parameters with larger error bars.
- **A1: Requirement**: "Point" estimate of the statistic (**see covariance requirements below, where L2 errors are captured**)
- **Cosmological Likelihood Implication**: At SWG level this will be made for checking purposes

Category B) Raw on-sky ellipticity: (ee) (ep) (pp)

- not corrected for any effects (except shape measurement systematics TBD)
    - Also validation test outputs
    - Also sanity-check outputs
        - New sanity-checks could be proposed through the configuration control process at any time
- Motivation: Input into Euclid likelihood analysis.
- **B1: Requirement**: "Point" estimate of the statistic (**see covariance requirements below, where L2 errors are captured**)
- **B2: Requirement**: Likelihood of the statistic P(D|2-point stat) or P(D|2-point stat) **- includes error propagation from L2 but not conditional on cosmology**
- **Cosmological Likelihood Implication**: At SWG level likelihood propagated into likelihood pipeline for cosmology P(theta|D)

Additional products

Transformations that need to be done to the theory to make it comparable with the data products. These are implementation-specific and will be captured at lower-level requirements (for each algorithm in LE3) but include as examples:

- covariance (data covariance)
- filter functions (including band power for example)
- mask correction function (if required) (e.g. mixing matrix)
- filter functions for correlation functions (2-point to EB)
- EB mapping for PS (1-point to EB)

General TBD Requirements

- Definition of “tomographic” bins
- binning for all methods (e.g. l- k- theta- etc. etc.)
- ...

Difference to real-space correlation functions/E, -B-mode functions

1) no mask correction necessary (needed only in covariance)
2) no shot-noise correction necessary
3) Curved-sky transformation from correlation function to E-/B-mode functions probably needs to be checked and developed

Are these Necessary Requirements for all methods

Those methods that are used in the actual likelihood for the DE parameters. Note that validation test 2-point statistics (specified in the validation and verification document) are not necessarily required to satisfy the minimum above (e.g. FoM).

- Curved sky
  - Issue discussed: l~10 (l ~ k r[z]) has information, but what about S/N/systematics on these scales. Curved sky is the “principled way” of doing this, flat-sky would have to include inter-tangent-plane effects. Flags up the missing scale-dependence of the systematics. This could be different for different science applications (e.g. Cosmological Constant (possibly, no one knows) doesn’t affect large scales directly).
  - Also have back up flat-sky implementations/approximations which are faster, and also may have requirements for having some flat sky analysis.
- Limber approximation (breaks down below l~50)
  - Does not affect most measurements. Most methods don’t assume this already (?), but there are plausible (not good) methods that would. Perhaps more of problem for pp and gp - needs investigation.
- Scale dependency:
  - Methods need to probe a minimum range that is specified by P(k,z) requirements (FoM) (maybe a trivial requirement, TBD)
  - Specify the redshift dependent k-dependent kernel (for projection method this translates to l- or theta-dependent functions).
  - Then possibly restrict to required modes; or demonstrate that the leakage from ranges outside this range are below some threshold (TBD).
- Science-level requirements:
  - Need to demonstrate that any method can achieve the Level 0 requirements - the approach to this is TBD (and would need to satisfy forecasting IST development processes)

Meta-Selection EMA functionality requirements:

- Ability to run LE3 code on the SHE, PHZ, SPE (L2) products outside the SDC/SGS/Euclid pipeline infrastructure
- Ability to make galaxy, sky (RA, dec), redshift, etc. selections on the catalogue

- Running time on hardware infrastructure/virtual environment

This discussion was about testing and validating of the data, and finding anomalies, and how to deal with those or how to report. Although we should make it easy to everyone in the consortium to run their own or prefered codes and analysis methods on Euclid data. However, the official procedure to detect and report “anomalies” has to be very strict, and follow a pre-defined procedure. We have to make sure that un-tested and un-validated code is not used to make “detections”, and

Methods Discussion (Th afternoon, Fr morning)

Power Spectrum Methods

General discussion on all methods, presenting overview and status updates.

Methods in Euclid now:

- Alsing/Heavens/Jaffe Tomographic Bayes-Cl
- Taylor/Asgari Tomographic Pseudo-Cl
- Brown/Whittaker Tomographic Pseudo-Cl - test intrinsic alignment, PCL.
- Balan Tomographic Pseudo-Cl and Bayes-Cl

    - PCL in LODEEN testing in LN sims. Not through maturity gates yets.Gibbs sampling for P(Cl).
    - Bayes-Cl - parts of the same code
    - Not noise corrected
    - assuming harmonic a_lm’s are Gaussian
    - healpix binning at the current time
    - PCL doesn’t touch mask, BCL does the infinite-variance thing
    - BCL need requirements - these need to be thought about and cf. to point-estimators (SWG).
        - Test code on Gaussian simulations (solution analytic). But does not test realism.
    - these are all Cat B methods - PCL is also Cat A.
    - one run week to many weeks - couple of days on multi-core (if/when parallelised)
    - need a Bayesian requirement on p(Cl) - SWG task?
    - need to test on simple simulations
    - PCL people will go off and start to compare codes, need to demonstrate requirements
    - agree to test, compare and pair down to 1 CPL approach and 1 Bayes approach.

- Kitching 3D Pseudo-Cl (and Swl)
    - In LODEEN. 5/10 test off check-list for maturity gates for PROTO-A gates
    - Effectively only Cat B right now, but this coded - to ok for reviews - Mll code is less mature
    - Also working on 3D spin-wavelets to generate 3D power directly (rather than 1-point estimator), and also may lead to a 3D-Bayes-Cl (PhD student Zoe working on this)
    - some slides (given to Sree for Milan report) here

Other:

- SvWKM02 band-power spectrum (integral over correlation fct.)
- Maximum likelihood (Hu & White estimator, is this just a prior on a Bayes-Cl?)
- PolSpice CF-to-PS (Challinor, used in CMB)

PK PF Actions

1. Keep developing 2 routes PCL & BCL.
2. PCL in LODEEN and should be able to demonstrate for Science Performance Review in 2017.
3. Internal discussion / competition in PLC team compared to Gaussian/lognormal simulations.
4. Need criteria to compare methods (run time, 1-pt estimator accuracy).
5. Result will be a single PCL approach (need ML at low-l?).
6. BCL - need requirements.
7. BCL tested on Gaussian simulations to test code.

3D-PK Actions

1. Test/set benchmark tests on fine-binned gaussian random field (from Henrique)
2. Compare project power to PCL outputs for sanity check (link to PCL group), set up this validation test
3. LODEEN gates continuing

Correlation Methods

Codes in Euclid Now:

- kd-tree (Athena)
    - Filter options: COSEBIs, Map-dispersion

Other codes:

- corr2 (Mike Jarvis' C++ code)
- brute force !??

Coes can provide pdf(2pcf|data), e.g. sampling over p(ell, phz, …)

General Discussion

- everything can be obtained through (integration of filtered) 2pcf.
- Cosmology would be done through COSEBIs.
- so basic LE3 products are xi+/- and COSEBIs.
- Other 2pt-stats would be used for sanity checks and validation tests. These would be calculated at the likelihood/SWG level.
- Need to add sanity tests using other 2pt stats.
- need to test 2ptcf and PCL estimates for passing maturity level 2.

Open questions

- Validation and testing: what are intermediate steps that do not go all the way to FoM?
- How do we get and test requirements on the likelihood?
- How to set requirements for Bayesian methods? - TBD (SWG).
- How to transfer information for samples to cosmology (KDE, Blackwell-Rao)?
- Low signal to noise issues
- Need to create validation/sanity tests that are the links between methods i.e. FT(CF)~PK, Projected 3DPK~PK, Prior BCL~PCL etc.

Actions (for real-space methods)

- Clarify use of xi+, xi-, and COSEBIs, and role within LE3 (output/validation)
- Think about sanity tests that are done with specific estimators (e.g. local parity tests?)
- Look at the Jarvis code for comparison ?

Covariances (Fr morning)

Discussion

- Model covariance: We need a covariance that includes cosmic variance. This will come from CSWG.
- Data covariance: do we actually need to compute this covariance, or could the error estimate be implemented in the sample of 2pstats?
- Ideally we would create many realizations of the Euclid survey and get the covariance from the variation between those realizations. That is probably too expensive.
- Different contributions can be separated, e.g. cosmology and shape measurement errors, but this has to be tested.
- Are correlations between data and cosmology covariance introduced, e.g. by mask that is related to LSS? Probably yes, but this can be dealt with from a model point of view, e.g. take the SGS mask and simulate this effect on N-body simulations within the CSWG.
- Do we really need the data covariance, will we never use it, if the full covariance will be produced by the SWGs?
- Data covariance is easy to produce, if just used for error bars and visualise covariance. The inverse, for use in a Gaussian likelihood, is the big problem.
- Validate data covariance by comparing “measured” covariance using one simulation of the Euclid survey with the same data procesing applied, to the true underlying covariance of that simulation. Probably iterative approach to match simulated cosmology to Euclid.

Agreed Plan:

- LE3 produces the **Data** *covariance*
    - Data covariance is useful for comparison with the full covariance in model testing
    - Alternatively could produce Monte-Carlo Realisations of data (probably simpler, or maybe more complicated…)
    - Also in comparison with the full covariance allows for a cross-validation of the simulation pipeline - by estimating a “data covariance” from sims (see below)
- cosmoSIMSWG inputs L2 (SHE, PHZ, SPE) errors, plus: mask outputs, cosmology, IA modelling and produces **full** *precision* matrix (inverse covariance)
    - This is then input into the likelihood pipeline along with LE3 data vector output and IST theory outputs
- This requires coordination of the cosmoSIMSWG and the SGS for release schedule - **action** to discuss this at the SGS PO/Science Lead/Garage day level

Recent references:

- Friedrich et al. (2015): Influence of different estimates on cosmo parameters
- Petri et al. (2016): Number of N-body simulations for covariance
- Blot et al. (2015): Testing wishart scaling for galaxy clustering
- Sellentin & Heavens (2016): Marginalisation over covariance - t-distributions
- Lin & Kilbinger (2015): approximate Bayesian Computation, likelihood-free estimation
- Taylor, Joachimi & Kitching (2012): Accuracy and precision of inverse cov matrix
- O’Connell et al. (2015): ‘new method’ for covariance matrix estimation for galaxy clustering

- Pearson & Samushia (2015): mock number reduction for covariance matrix estimation
- White & Padmanabhan (2015): simultaneous cosmological estimation of covariance and parameters
- Mohammed & Seljak (2014): Analytic predictions for matter power and covariance
- Taylor & Joachimi (2014): extending wishart calculations
- Morrison & Schneider (2013): Wishart calculations
- Takada & Hu (2013): super-sample covariance
- etc… there are loads…. :-l

SDC, hacking session **(Fr afternoon)**

Presentation by Bertrand. Slides available here:

2pcf milestones

- Mar 2016, ML1B
- Jun 2016, ML2A, before technical key point

At the moment, SDC only supports parallelization with openmp, not MPI. Exceptions for LE3 can be made, needs to be proposed to Christophe Dabin/System Team.

SDC-FR infrastructure:
Standard: 40 cores, 3 GB RAM.
Huge queues: one core, 16 GB.
Huge multi queues: 40+ cores, 5 GB.

Validation, simulation (Fr afternoon)

- Simulations for validation (real- **and** Fourier space, but not necessarily same kinds of sims)
- Minimal simulated catalogue consists of ra, dec, e1, e2 z, (, w)
- Full-sky, non-flat, or small patch sufficient for a start?
    - PCL and BCL need full sky, 3DPK and CF can test on smaller patches
- Can apply (pseudo-)Euclid mask
- Different methods calculate the same quantity should run on the same simulations.
- Available:
    - Michael, Lee, and Sree can create Gaussian, correlated simulations, arbitrary number of z bins, full-sky pixelated healpix maps. Can do IA and galaxy clustering, magnification.
    - Benjamin + Henrique's 3D correlated shear catalogue (Gaussian, log-Normal), 100 deg^2, this already exists (TK can send)

Actions

- Need to define metric to compare different methods
- Otherwise, for the time being we can use different simulations, and define steps towards a medium-time goal to use common, realistic simulations.
- Sree, Lee, Michael, Justin to start running stuff within 1-2 months

General actions from the Meeting

- have chat before Lisbon in one of the LE3 teleconf (Jean-Luc+Benjamin).
- don’t fix a face-to-face meeting yet and see how it goes
- set up slack system? or mailing list, redmine, …? Discuss it later during teleconf